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THE ROAD TO CHEPHREN'S QUARRIES

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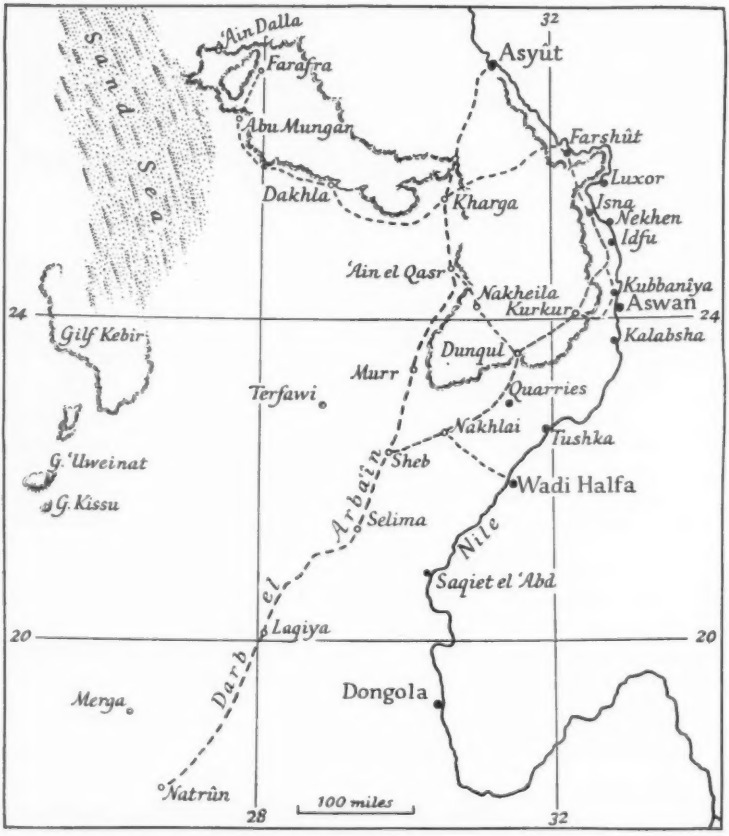
MOST of you have heard of the Darb el Arba'in, the wicked old camel route of forty long days between El Fasher, the capital of Dar Fur, and Asyut, by which gold and ivory, gum, skins, ostrich feathers, and slaves were brought in medieval times from the Sudan through Kharga Oasis into Egypt. Through traffic along this route ceased during the period of Dervish rule in the Sudan, and has never revived.

But there has always been a certain demand for natron in Upper Egypt; a Ramessid inscription on Elephantine Island speaks of, among other trades, "natron-gatherers," and, though the practice of embalming has long ceased, natron is still wanted for making soap, chewing with tobacco, cleansing water-skins, and bleaching linen. So throughout the centuries sporadic attempts have been made to exploit the natron deposits in the Sudan, and Bir Natrun, on the Arba'in road, 700 miles south of Asyut, has served as a meeting-ground for Jahama and Billi tribesmen from Upper Egypt, Hawawir from Dongola, Kababish from Kordofan, Bedayat and Qura'an from the far west. There is a spice of danger in the enterprise, for an Egyptian caravan was massacred at Laqiya in 1926 by a Qura'an raiding party. The price of natron at Asyut has been given to me by members of two expeditions as £E.2 a hundred-weight and as £E.7 a camel-load. Both my informants declared they had lost on their journeys. Still, one of the Jahama assured me that there was lots of good shooting once you got into the Sudan, and that in particular there was a depression, only a little way off the track, filled with ostriches and unicorns. This Nasamonian spirit still persists, and the adventure was renewed this year, for, coming up into Kharga from the south, we overtook thirty-eight camels grazing at 'Ain el Qasr after their wearisome journey from Natrun.

Some have wondered whether the ancient Egyptians used this Darb el Arba'in, particularly the Sixth Dynasty noble Harkhuf, who brought the famous pygmy from the Sudan for the youthful king Pepi II. For two reasons I do not think they traded along the Darb el Arba'in itself. First, there are

no very ancient Egyptian remains in the Kharga Oasis (in fact Miss Caton-Thompson has suggested that it was not colonized till after the Persian invasion in 525 B.C.), and secondly the Egyptians were not till then in possession of the camel.

There are waterless stretches on the Arba'in rather too long for donkeys. There is, to begin with, the stretch from Asyut to Kharga, just over 125 miles



The Darb el Arba'in

of bad country, and a stretch of similar length in the Sudan from Selima to Laqiya, while from Laqiya on to Natrun there are more than 155 miles. Now the poor donkey's absolute maximum is five to six days with the water he carries, say 115 miles in cold weather, and this drops to three nights or 60–65 miles in hot. So we may conclude that the main Darb el Arba'in itself was hardly practicable for the ancient Egyptians. But the people of the oases could communicate with the Sudan by following the Arba'in from Kharga

through the wells of Murr, Kiseiba, Sheb, and Selima to Saqiet el 'Abd at the south end of Halfa Province. Traders coming from the Sudan to Egypt could leave this route at Sheb about 100 miles west of Halfa and continue their way through the desert wells of Nakhlai, Dunqul, and Kurkur to Aswan and Isna. The longest stretch on this route was between Nakhlai and Dunqul, 105 miles, but during the Old and Middle Kingdoms there may have been an intermediate station.

In earlier days the predynastic Badawin found the western desert easier to travel in, and followed the rains everywhere. From the vivid rock-paintings discovered in the mountains of Kissu, 'Uweinat, and the Gilf Kebir it is apparent they possessed long-horned cattle and settled their quarrels with the bow and arrow. Even in those early days there were disputes between brown-skinned Libyans and black negroes. These rock-paintings, as distinct from rock-drawings, have not yet been found in the Nile valley or the eastern desert. But they show a remarkable resemblance to a Middle Predynastic painting of men and animals discovered by the late Mr. Quibell at Nekhen, which the Greeks called later Hieraconpolis.

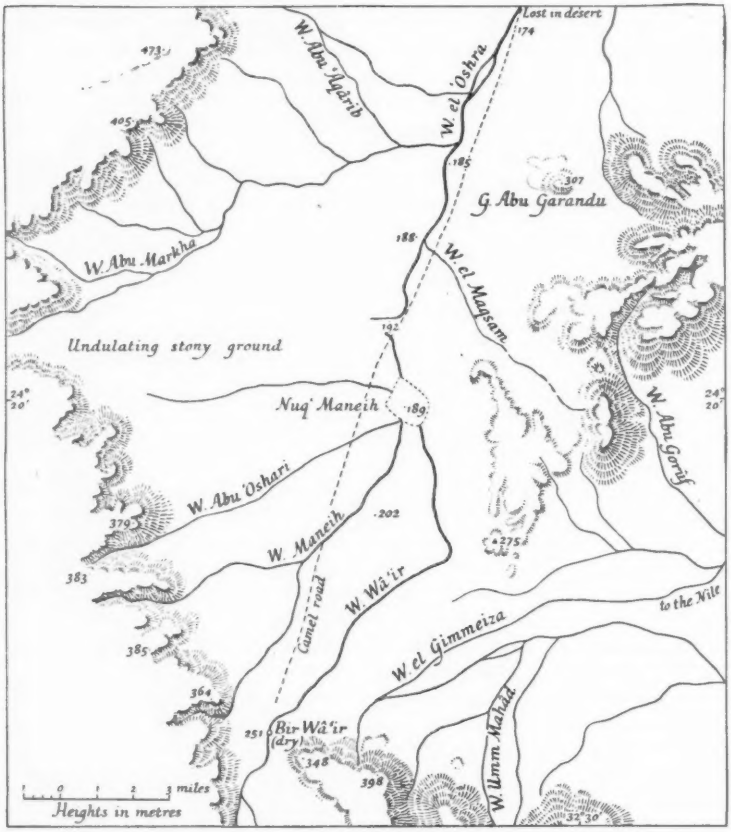
Nekhen, the City of the Falcon, lay between Isna and Idfu, and was doubtless the terminus in those days of the branch from Sheb on the Arba'in road. For it was the capital of Upper Egypt until the union of the two crowns, and remained an important town until the close of the Old Kingdom. Here too were found the famous slate palette of Narmer and the realistic copper statues of Pepi I and his son. Now the road strikes the Nile at Isna and continues beside the cultivation to Armant, where it is joined by a direct camel road from Kharga.

In early dynastic times, before the Old Kingdom, this Sheb–Nekhen road must have become the only channel of communication between the drying-up settlements of Libyan culture and Egypt. And one of the last of these desert settlements to give in must have been the area between Sheb and Terfawi, where water even to-day is close to the surface and the addax antelope still lingers. But, just before historic times, rain became so scarce in the Libyan Desert that most of its inhabitants were forced into the Nile valley. With donkeys as their only transport animals even the oasis-dwellers in Kharga and Dakhla may perhaps have found it easier to trade with the Nile valley by roundabout stages through Nakheila, Dunqul, and Kurkur to Aswan than by crossing direct from Kharga to near Abydos, where the waterless section exceeds 90 miles. We know however that the Egyptians of the New Empire communicated with Bahariya Oasis, 103 miles from the Faiyum, by the Wadi Raiyan, or 115 miles from Bahnasa on the Nile.

Stay-at-home people hardly realize the enterprise, I had almost said the ubiquity, of the Libyan Badawin. At the present day they care so little for distance that most of the Bahariya date-crop is exported not to the Nile at all but to the sea coast, a distance of 190 miles. A youthful friend of mine, Wanis, who lives near El Dab'a, on the Mediterranean, took his camels last year to graze in Farafra, more than 300 miles away. The early Badu had just as much exploring spirit, and I am quite sure that if Wanis's First Dynasty ancestor, who had to do much the same sort of thing with a donkey, came to life, he would lament the good old days and call the lad a softy.

My paper now falls into two parts, first a general description of the Isna–Sheb road, and secondly a personal narrative of a visit last year to the ancient quarries which have lately been discovered beside it.

As regards the road, the Survey have just been mapping the northern half of it, and the maps of Khalaf effendi Mursi and Said effendi Afia, my assistants, show some features of interest. For example about 90 kilometres south



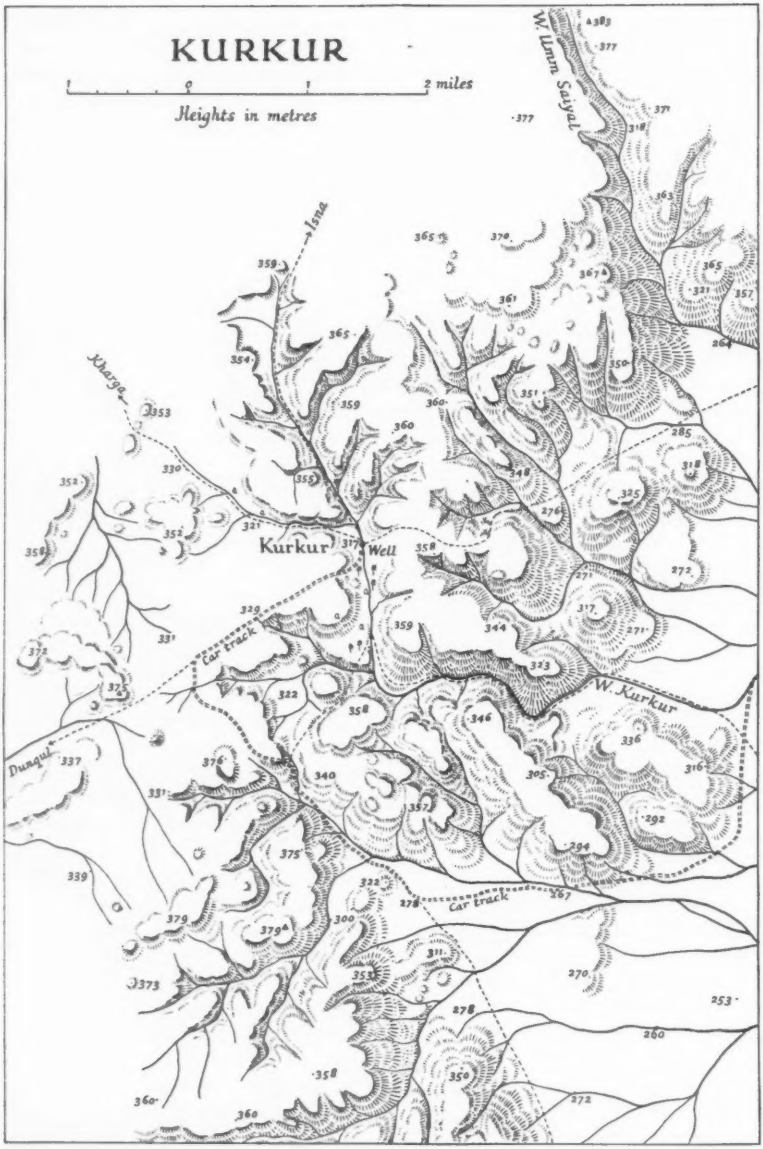
The Nuq' Maneih pan

of Isna the road passes behind Gebel Barqa, a 1600-foot outlier of the limestone escarpment, and here, at some time since the last desiccation, the wind has interrupted the northward drainage of the area by scooping out a hollow in some soft marls. But subsequent torrents down the old drainage lines have nearly overtaken this erosion by wind and filled the incipient Faiyum nearly to the brim with their downwash. The clay pan thus formed is called Nuq' Maneih, and has certainly in former days been cultivated after rain.

This season we found there grindstones, Third Dynasty pottery, a polished axe, stones to which beasts had been tethered, and graves covered with mounds of stones. An individual inside one of these was buried flexed on the left side with the face due east, but with nothing in the grave. But to console us Ali Kheir, who was sent to build the cairn on Gebel Barqa, returned with the treasure-trove of two solid silver anklets which he found lying on the summit of that mountain. Farther south, the Sheb road enters the defile of Wadi Wa'ir, impassable to our cars, and we made a detour to rejoin it at the wells of Kurkur. Here we entered the basin of the Khor Kubbaniya, and found to our surprise that this part of the Libyan Desert, and this part only, belongs to the Nile basin. For the great limestone cliffs that run from Luxor and Isna to Kurkur, Dunqul, and round to Kharga are high near Kurkur, and the run-off from them after rain reaches the river.

From the east the Nile receives many great tributary wadis, dead rivers we may call them, but from the west in Egypt only three. The Wadi Kubbaniya comes down 10 miles north of Aswan, the Wadi Kurkur at Dabod, and the Wadi Kalabsha at Kalabsha. The Wadi Kurkur is the largest of the three. Just before leaving the limestone escarpment it cuts through some water-bearing beds, and a beautiful gorge filled with date palms, *dom* palms, and acacias is the result. I hesitate to call Kurkur an oasis because it has neither permanent inhabitants nor cultivation, and the Arabic *wah* and the Greek *oasis* seem to imply their existence. But it is a natural garden or park with steep limestone walls, and contained last January four temporary inhabitants, one of them a woman, and all craving for tobacco. They were 'Ababda from Daraw, possessing several sheep, a camel, a dog, and a donkey, and they knew all the world as far as Dunqul and no farther. Kurkur water can be drunk, though it has a high saline content, and the water of Dunqul, the next set of wells on the way to the Sudan, is really good. At least it is so at "Little Dunqul," for there are two sets of wells called Dunqul, about 2 miles apart. The main Dunqul is the northern, for though the water there is not so good, yet it has grazing for animals. But it has not yet been reached by car, while at Dineiqil or "Little Dunqul" cars have been driven right up to the wells. These are on a shelf half-way up the escarpment, and can be seen 20 miles away. In the season there are plenty of dates and *dom*-nuts. We saw no antiquities at either Kurkur or Dunqul, except some very old cairns at the latter.

The road between Dunqul and Nakhlai we found well marked in places by numerous parallel camel paths, but with very few camel skeletons, and those very decomposed. Just before reaching Nakhlai there is a dune belt, and the camel tracks run straight at and under some of the largest dunes. Mr. P. A. Clayton had observed this in 1931, and this year we saw that his car tracks had in turn been swallowed up. These barchans, an advance-guard of the Kharga column, are actively marching south. At Nakhlai, a low hill capped by a palm tree, water can be obtained anywhere by digging to a depth of 3 or 4 feet round a sand-covered hill. The taste is good, but it is full of a milky sediment, and the flow is so slow that it took us three hours to dig two holes and obtain 5 or 6 gallons. Mr. Clayton noticed a second water-level on top. He says: "Near the top of the hill there is an outcrop of sandy clays, and here the desert foxes have dug their own little well, with water standing


KURKUR
2 miles
Heights in metres
W. Umm Saiyal
Isma
Khargo
Kurkur
Well
Car track
Dunqul
W. Kurkur
Car track

in it at 208 metres above the sea. The supply is not large, but the tiny hole refills gradually."[1]

Forty miles farther to the west, approaching Sheb, scattered clumps of *dom* palms become common and there are a few *Zizyphus* trees. Water is near the surface over a very large area; gazelles and foxes are common. The country is a sand plain with a few scattered hills. At Sheb there is a block-house, and one joins the Darb el Arba'in with its innumerable camel skeletons. Here the main well is sanded up and bad in quality, but better water can be obtained by digging elsewhere. Sheb is within walking distance of Halfa (105 miles). A car patrol had to prove this some years ago, when two new cars burned out their gears there.

After the drying-up about Pyramid times the desert routes went gradually out of use until the introduction of the camel, when they revived just as the English coaching roads revived at the invention of the motor car. Then the Persians and Romans explored everywhere. And later again the camels brought raiders from the Sudan. Just as the Egyptian army had to occupy Kurkur, Nakhlai, and Sheb to protect Egypt from the Dervishes, so must the Romans have had to occupy them to save Egypt from the Blemmyes. Khalaf effendi Mursi picked up a Roman amphora on the road near Kurkur last May.

Nowadays imports into Egypt from the Sudan by the desert are restricted to camels and contraband tobacco; and, although the Arba'in and its branches are quite dead, there is a live road nearer the Nile which runs to Kubbaniya from Wadi Halfa, as the pathetic remains of dead camels declare. For Aswan itself is a river port and access to it from the desert rather difficult, so that Kubbaniya on the west and Daraw on the east have taken its place. But Kubbaniya was only a port of call where the camel caravans watered and went on, still in the desert, to Isna and Farshut. Why did they avoid the cultivation? I think it was because of the unsettled governments of those days, and the desire to avoid local taxation by the Mameluke beys and kashefs. William Browne, the first European to use the whole Darb el Arba'in, attempted first to pass into the Sudan by the Nile from Aswan, but was obliged to give it up and return to Asyut. The desert was safer in those days, and one had to keep well away from the river.

The Nile above Kom Ombo runs in a 300-foot gorge through a deeply incised sandstone plateau, and the flood-plain is narrow or non-existent, so that the camel roads from the Sudan have to run well inland to avoid the bends of the river as well as the continual ascents and descents into minor tributary wadis. They do not enter the cultivation of Egypt until this difficult country has been left behind. One may perhaps have wondered why there is no railway line between Aswan and Halfa; the intricate nature of the sand-stone country is the answer to that.

The evidence is clear of much traffic along all these ancient roads in the past; they are rutted deep with scores of parallel camel tracks, and beside them lie thousands of little gravel heaps on which the caravans of the past cooked their bread. And history here as elsewhere had a way of repeating itself. In the time of Napoleon the villagers of Kubbaniya used to combine

[1] *Bull. Soc. Géogr. Égypte* 19 (1936) 259.

with the 'Ababda to send an annual caravan of fifty camels to bring alum from "Psafa," which lay ten days away to the south-west. The route lay through Kurkur and Dunqul, and "Psafa" (=Abu Sa'fa) is clearly another name for Sheb. Furthermore, according to Burckhardt in 1816, the Qarrarish Arabs from Halfa used to go to Sheb for alum and fight with the inhabitants of Kubbaniya whenever they met them there. Compare with this Harkhuf's account of his third journey in the reign of King Merenra. "I set out *on the road of the quarries*, and I found the Chief of Yam [somewhere between Halfa and Dongola] going to Temeh [south Libya] to smite Temeh as far as the western corner of heaven."[1] Harkhuf accompanied this negro shaikh to south Libya, perhaps by the Arba'in road up to Kharga, pacified him, and induced him to act as escort to his, Harkhuf's, expedition to the Sudan. No doubt this encounter took place at Sheb or Selima, and possibly some dispute about alum was at the bottom of the affair. The Dervishes repeated the exploit of the Chief of Yam in 1893, raiding up the Arba'in road to Kharga and Dakhla oases.

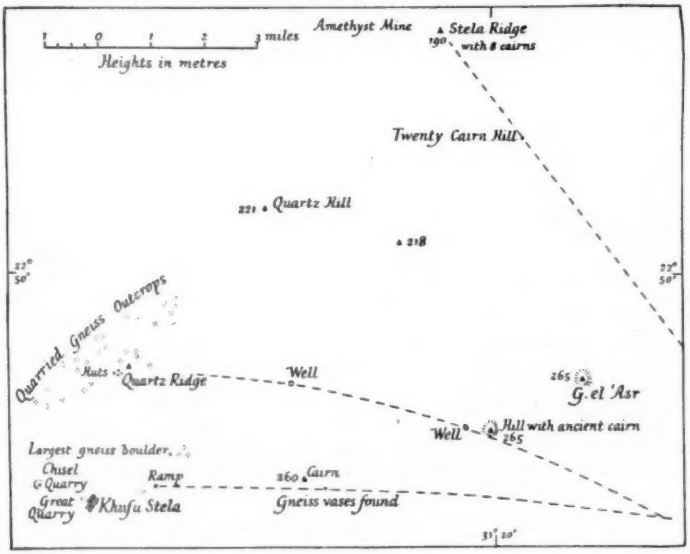
But what were the quarries of which Harkhuf speaks? I believe them to have been the quarries, already ancient in his day, from which the stone for the famous statues of Khafra, or Chephren, was obtained. Chephren was the builder of the Second Pyramid, and in 1858 Mariette Pasha, excavating near the Sphinx, found in a well six sleek shining statues of this king, life-size, cut in a greenish stone which he called "diorite," but all damaged or broken except one. This survives to-day in the Cairo Museum. It was for long the earliest piece of statuary known, and is one of the few examples that have come down to us of sculpture in this "diorite," a rock so hard that it will cut like a file into marble or alabaster. Yet many generations of sculptors and stone-cutters must have gone by before Egyptian art attained such perfection. The unknown artist has presented Chephren without any regalia, and yet with such an air of serene dignity that one realizes at once that here is a king, and a king likely in those days to have been revered as a god. There is nothing of the warrior about Chephren, but a tranquil air of self-confidence that befits one who has a plan or a religion to resolve all the difficulties of his country. Altogether the statue is a masterpiece in stone worthy to set beside the wooden Shaikh el Balad or the copper Pepi as the highest achievement of Egyptian art.

It must however be confessed that the geologists will not now admit the name "diorite" for this greenish stone. They use diorite for an unaltered species of plutonic rock, and this, though it has rather a similar chemical composition to a diorite, has been so altered by movement and pressure that it has acquired a foliated structure. They want to call it "anorthositic gneiss." I shall abbreviate that to "gneiss" for the remainder of the paper.

It came about that three-quarters of a century went by after Mariette's discovery before the place whence Chephren obtained his stone was found. Then in June 1932 a frontiers car patrol strayed in a sandstorm from its course between Dunqul and Nakhlai and found the quarry 500 miles out from the Temple of the Sphinx and 50 miles out from the Nile, in such a backwater of time and space that since Twelfth Dynasty times no one had visited it.

[1] Breasted, *Ancient Records*, vol. 1, p. 153.

Spinks Pasha and Colonel Hatton, the finders, did not know at the time that the quarry was Chephren's. They returned later with the curator of the Cairo Museum, Rex Engelbach, and brought back inscribed stones of Dadefrê, a petty king who reigned between Cheops and Chephren, Dadkerê of the Fifth Dynasty, and of Amenemhat III, a great king of the Twelfth. Two sites were located and two problems solved. The quarries themselves round Quartz Ridge revealed whence the monarchs of the Old Kingdom got their gneiss, and at Stela Ridge, 7 miles to the south, eight great cairns and stelae commemorated as many Twelfth Dynasty expeditions to a mine of carnelian and amethyst during the reigns of Amenemhat II, Amenemhat III, and Senusert I. Carnelian is common in Egypt, but until this find amethyst was only known



Chephren's quarries

from one small working at Bir Abu Diyeiba in the eastern desert. The Eleventh and Twelfth Dynasty ladies were especially fond of carnelian and amethyst beads, and now we know where they were obtained.

The quarry lies 10 miles off the ancient road, and was certainly worked as early as the time of King Kha-sekhem-ui of the Second Dynasty. It was probably discovered in predynastic times when gold-prospecting began. It occurs on the southern limit of a large igneous outcrop of a dark-blue granite whose northern edge is traversed by this branch of the Arba'in, and the occurrence of an ornamental stone beside a quartz vein may have drawn the attention of a disappointed prospector. I may say that I have had this quartz tested, and there is no gold in it.

The quarries were exploited throughout the period of the Old Kingdom, that is during the Third, Fourth, Fifth, and Sixth Dynasties, and again during

the Twelfth. Then an even more severe desiccation set in which has lasted until the present. This caused the abandonment of the quarries; perhaps directly through the failure of their local water supply or indirectly through the invasion of the Hyksos and the collapse of the Middle Kingdom.

The time that General Spinks and Colonel Hatton were able to spend at the quarries was very limited, but their discoveries were of such importance that they appeared to me likely to lead to others, particularly as the route by which the gneiss was taken down to the Nile was still unknown. But it was not until February of last year that I was able to persuade our Director-General, by this time Dr. Hasan Sadek, to grant the necessary credit for an expedition. Most fortunately Mr. Engelbach was free for a week and able to accompany us. He arranged to meet us at Aswan.

We left Cairo on 1 February 1938, and ran up the Nile valley 10 miles past Nekhen to its successor as the City of the Falcon, Idfu, whose undamaged Ptolemaic temple still dominates the town and countryside. Thence we followed the desert track by the west bank to Aswan. Here the usual entry and exit at the Dam involves some switchbacking over drift-sand and cannot be recommended for cars without airwheels.

While we waited for Engelbach, our camp was pitched about half a mile from the west end of the Dam on a black sandstone ridge between valleys of orange sand, and its atmosphere was electric from the very start. On February 5, while we were putting out an advance dump of petrol and water 60 miles to the south, a thunderstorm broke; and on our return Khalaf Mursi reported that one of his instruments had sparked and that his pencil had hissed at him when held in a vertical position, though not in a horizontal one. We slept that night in little bivouac tents, and at one o'clock in the morning my wife woke me to show me St. Elmo's fire. Both the metal tips of her tent poles were shining quite steadily and brightly, her blanket rippled with sparks, and everything in her tent was electrified. This continued for five minutes, and then the poles ceased to glow. A heavy black cloud was slowly passing overhead. She returned to bed, but in a quarter of an hour rushed out again. This time she had seen two balls of fire, each as big as a shilling, float through the tent. One ran along a horizontal cord before it disappeared. Now thoroughly frightened, she remained in my tent till the dawn. Next morning a stiff breeze chased all the clouds away, but we were left with a feeling that the expedition was going to be an unusual one.

On the afternoon of February 7 Engelbach arrived by aeroplane, and we started immediately. There had been some doubt about the exact position of the quarries, and Major Bagnold's 1933 expedition had passed close by without seeing them. But by 4 p.m. next day we had rediscovered Stela Ridge almost exactly where Colonel Hatton had put it, that is to say, 45 miles north-west of Abu Simbel, and admired the eight great cairns raised by the stone-cutters Si-Bastet, Iny, and Nakhty for the Amenemhats, and by Henenu, son of Mentuhotep, for Senusert I. We pitched our camp about midway between the two ancient sites, well pleased with our speedy and safe arrival.

But the first appearance of our landscape was a little disappointing. The cliffs of the Kurkur–Dunqul scarp, locally known as Sinn el Kaddab, or "Liar's Tooth," had disappeared below the northern horizon, and we were

E. A. M.

Dom palms near Sheb

E. A. M.

General view of Sheb

E. A. M.

The Sheb well

Egyptian Museum, Cairo

Chephren

E. A. M.

The Khufu stela

left in a plain with only the slightest of features. There were neither hills nor definite quarry-faces to look at. Only heaps of boulders emerged from the sand, weathering dark-blue for the granite and bright-blue for the gneiss, with a few mounds of dazzling white quartz. Some shallow drainage lines meandered in a northerly direction. The large rubbish heaps round the gneiss outcrops showed the ancient quarries near Quartz Ridge where the frontiers patrol had made their first discovery. This ridge and Stela Ridge are rises of about 20 or 30 feet only, yet they can be picked out by the eye several miles away, and by field-glasses much farther. Quarries is almost too dignified a word for these Egyptian workings. The gneiss occurs as boulders largely buried in sand, and all the ancients did was to pry out the largest stones they could find near the surface. To economize weight, these were dressed to nearly their final shape before being despatched to the Nile.

Early next morning we separated for work; a party returned to bring in the dump, my wife and Engelbach left for the quarries to see what they could pick up, and I went to reconnoitre the country between us and the Nile and to build cairns for triangulation. About 5 miles to the east the country changed completely, and an archipelago of picturesque sandstone knolls rose out of the golden sandsheet. Not a sign of life, past or present, was seen anywhere, except some very ancient cairns, till at noon I came upon five 40-lb. lumps of the gneiss lying together, probably where a donkey had died under them in Twelfth Dynasty days. They had been roughly shaped into the form of bowls, but had not been hollowed out. We threw them into the car and recorded their position, for they undoubtedly marked a point on the road to the Nile.

About sunset I ran down to the quarries to see how the archaeological party had been getting on. In the morning they had ransacked various quarries without finding anything of interest, but in the afternoon they had found an immense new quarry, the main working in fact, and here, on a platform between two great gneiss boulders, stood a black granite block bearing an inscription of Khufu or Cheops, the builder of the Great Pyramid. Before it, 12 yards away, in a lower and humbler position, a stela of Sahurê, a king of the Fifth Dynasty, was stuck rather carefully into the sand. Both these were quite legible. All the sandstorms of over four thousand years had made very little difference to Sahurê and none at all to Khufu. When I came up, the discovery had not long been made, and my wife was still photographing the inscriptions, which Engelbach had whitened with chalk. The cartouche of the great king was plain, and the inscription was afterwards read as "The desert workshop of Khufu."

Of this Khufu who caused the Great Pyramid to be built, we know hardly anything more than the dimensions of his tomb, yet the vastness of this is sufficient to prove him to have been one of the greatest of monarchs. Moreover he is depicted at the turquoise mines in Sinai as smiting an Asiatic chief, while alabaster was taken in his name from the Hat-nub quarry near Tel el 'Amarna. That his mother's empty sarcophagus was reburied hastily with much golden treasure led Doctor Reisner, its discoverer, to infer that the king's ministers were afraid to tell Khufu that the Queen's mummy had been stolen. No statue of the great king has survived (this alone conveys

a hint that he was unpopular), and only a tiny statuette from Abydos shows us an alert and vicious countenance. Literally that is all we know of Khufu. Sahurê, the Fifth Dynasty king, whose smaller stela was erected in front of that of Khufu, was already known from an inscription at Tumas to have sent a large expedition to Nubia.

It is strange that Chephren, the only king, so far as we know, who had the gneiss cut into anything as large as a statue, is not commemorated at the quarries. Perhaps he took advantage of some large blocks brought down by Cheops or Dadefrê, his predecessors.

On the 10th I sent a party south-eastwards to bring us water from the Nile, which I thought they might reach near Abu Simbel, while we continued the examination of the quarries. About a mile east of the main or Khufu quarry was a large ramp for loading blocks, solidly constructed of large pieces of the gneiss. It was about 8 yards long and rose at its face to about 5 feet above the original ground-level. In clearing the sand at its face, two parallel trenches were discovered running straight away from the ramp which still present an unsolved problem. They were about 18 inches deep and wide. The course of one of these was followed up till it reached ground-level about 10 yards east of the ramp. It was perfectly straight, and its width remained unaltered throughout. Fragments of early Old Kingdom pottery were found by Engelbach in the filling. From the height of the ramp it certainly looked as if carts had been loaded at it rather than sledges. But their sledges were high off the ground, and the use of wheeled vehicles at such an early date is quite unknown. Two other ramps were observed near the Khufu platform, but neither was in such good condition as the one just described. About 120 yards east of this ramp was a great quantity of chips and burnt gneiss where a large block had been dressed before it was sent away. The use of fire-setting in the ancient gold mines is described by Agatharchides, the tutor of Ptolemy X, but this discovery shows it was known at least as early as the Middle Kingdom.

The administrative centre of the quarries may have been in some huts on Quartz Ridge where Spinks Pasha and Colonel Hatton found the stelae of Dadefrê and Amenemhat III. Outside lay a large quantity of broken jars, about 3 gallons in capacity. We cleared the largest room in these huts without finding anything, but outside it were some roughly shaped lumps of gneiss, one of which was marked in red ochre with a small cross and a bird. This we brought in for the Museum.

Two excavations, presumably well sites, were found this year while driving from the huts on Quartz Ridge Nilewards to a hill marked by an ancient cairn, which itself formed the first landmark on the road to the river. The first site was met with almost immediately after passing out of the igneous area into the Nubian sandstone at 5 kilometres from Quartz Ridge, and the second at 10·2 kilometres just before reaching the "Hill with ancient cairn." The excavations were very roughly rectangular and about 25 metres square, and the spoil had been carried well clear of the centre of each excavation, showing that the ancients had expected to bore deep. If Dr. John Ball's hypothesis of a general water-table under the Libyan Desert be correct, one would expect to meet with a permanent water supply in this district at about 140 metres above the sea, while the surface ground-level is about 200 metres.

General view of Kurkur E. A. M.

Loading ramp at Khufu E. A. M.

E. A. M.

Parallel trenches at the face of the ramp

E. A. M.

Halfway Cairn on the road to the Nile

Parallel trenches at the face of the ramp

Halfway Cairn on the road to the Pass

Yet the amount of spoil hardly seemed to indicate the digging of a 200-foot well at either place. Everything however was so masked in blown sand as to make precise estimation impossible. These wells would have afforded a welcome midway supply between Dunqul and Nakhlai to Harkhuf on his way to the Sudan. After his expedition to south Libya with the Chief of Yam he probably went either into Halfa from Nakhlai or from Selima to Saqiet el 'Abd.

To the north of the second excavation we found on a low hill a camp site with broken Middle Kingdom pottery, ashes, remains of ovens, and some plugs of dried Nile mud. Careful search was made for seal marks on these latter, but none were found. A rock on the top of this hill had been completely enclosed with a rubble retaining wall about 4 metres by 3 metres, and outside this facing exactly north-west was a place where perhaps a stela had formerly stood. Hoping to find an inscription on the rock or some cache of tools, I had the retaining wall removed, but nothing was found except the shell of an ostrich egg, intact save for a small hole which showed it had been a water-bottle. Broken ostrich-egg shells were found elsewhere fairly commonly scattered in and round the workmen's dwellings.

To resume our narrative. The water party returned on the evening of the 10th and reported they had found good going for 50 miles all the way to the Nile at Tushka, called by our fathers Toski, where General Grenfell repelled the Dervish invasion of Egypt in 1889. We came to the obvious conclusion that the old road to the Nile must be sought in this direction.

On the 11th Engelbach and I visited Twenty Cairn Hill, another low ridge from which the workmen coming from the Nile valley got their first sight of Stela Ridge and its amethyst mine, or their last as they went away. The hill was crowded with little cairns, some quite insecurely built. I have seen two other such places, one on the Qena–Quseir road, where travellers first glimpse the cliffs of the Nile valley, and a second at Kalabsha, in Nubia, where a desert road descends to the Nile. It is the custom of modern travellers at such places to pray and mark the spot with a few stones, and no doubt it was the custom of the Twelfth Dynasty travellers too.

On the 12th a very fine copper implement was found on the surface in yet another new quarry about a mile north-west of the Khufu or principal quarry. This new quarry was also dated by pottery to the Old Kingdom. The tool is a mason's gad rather than a chisel, for it has no cutting edge but was used for levering blocks apart. Its inscription has been read by Mr. Alan Rowe as "Kamu: bow watch: Southern Libyans." Mr. Rowe has pointed out that the large labour crews of the Fourth Dynasty received picturesque, almost ribald, names after some king or prince, such as "Mycerinus is drunk" or "Mycerinus excites love," and were divided in nautical fashion into port, starboard, bow, stern, and main watches, which were again subdivided into gangs. Here Kamu is doubtless the name of some hitherto unknown royal lady. This copper wedge had a black patina when found, but has since gone green in the more humid air of the Cairo Museum.

It is clear from the inscription on this copper tool that the people called Temehu or Southern Libyans were employed in the labour gangs at the quarries. These are the same people that the Chief of Yam was going to smite

as far as the western corner of heaven. They could hardly have been recruited at the quarries themselves, but must have come either from the group of wells near Sheb or much more probably from the Nile valley. A tentative case seems made out for their equation with some of the non-negroid human material, possibly part of the C group, found by the Archaeological Survey of Nubia.

That same afternoon we moved camp about half-way down to the Nile in order to study the ancient road. We found it beaconed by large well-built intervisible cairns on the hill-tops, while in its latter half the actual path was well marked by small cairns and fallen pieces of gneiss. When we camped, my attention was drawn by my tracker, Ali Kheir, to an upright object about a kilometre off, too motionless for a man, and too slender for a rock. Driving up to it, it proved to be the Halfway Cairn, 38·7 kilometres by speedometer from the huts on Quartz Ridge and 38·9 from the Omda's house in modern Tushka. It was a very fine cairn indeed, four thousand years old and as good as new, built out of hard silicified sandstone blocks in a way that went straight to a surveyor's heart. I have built some hundreds of good solid desert cairns myself, and the idea that some of mine might survive a few thousand years pleased me greatly. This cairn contained a niche for the insertion of offerings, and in this respect resembles exactly a cairn of unknown date in Wadi Iqna in south Sinai which the Arabs still venerate. Another very similar cairn stands at the foot of Gebel Waqif on the Arba'in road about 80 kilometres south of Kharga Oasis.

Next day my wife and Engelbach tracked the ancient road from one piece of fallen gneiss to another, and from little cairn to little cairn till they reached the Nile. They found a Quarterway Cairn almost as big as the half-way one. Here and there were camping places, usually in the open. Occasionally on harder ground they saw countless parallel trails, too thin and straight for camel tracks, that showed where the donkey caravans had taken provisions up to the quarries and brought smaller pieces of the gneiss down. No cleared track for sledges or carts was seen, and the cairns continued more or less in a straight line when rough ground was met with.

The condition of the cairns, the unobliterated donkey tracks, the undisturbed stelae, and most conclusively the find of the copper gad on the surface, all went together to show that no one between the departure of the last Twelfth Dynasty working party and Spinks Pasha's arrival had been to the quarry or used the road. True, a hole in the sand, a ring of thrown-out stones, and a broken amphora at Stela Ridge showed that a Roman patrol had preceded that of the frontiers there, but at the quarries themselves there was no sign of a visitor.

On the old battlefield of Tushka we lost the trail, but in 1939 my wife recovered it and found it led down firstly to a lozenge-shaped enclosure about 2 miles out of Tushka, next to the remains of a considerable camp, and finally to a large heap of stones adorned with flags, which the modern inhabitants of Tushka revere as the tomb of Sidi Ahmed. Tushka was full of unconsidered trifles of every age. In a couple of hours she snapped up twenty stones with Coptic inscriptions and the fossil bones of some animal from the gravel of an old Nile bed, and photographed two hieratic inscriptions. One recorded

the name of a scribe Para'emhab (read by M. Czerny), the other was illegible.

Last year we were obliged to head for home on February 14 and had an uneventful run to near the Dam. Before dawn Engelbach left to catch the aeroplane back to Cairo. He had had a busy week. Fate reserved for us one more surprise: our beginners' luck held good to the end. We left at half-past nine for Idfu and Luxor, and 4 miles from camp, while crossing the Aswan–Kurkur road, the leading car passed over a sandstone stela face down in the sand. Leaping from the car, Ali Kheir turned it over. It bore two little figures, an archer and his captive, and a single line of writing: "In the year 18 . . ." It may be Twelfth Dynasty in date, for an equally laconic inscription "In the year 18 . . .," together with the cartouche of the gloomy Senusert III, is known from Amada in Nubia. But as to what happened in that year of his reign we do not know. Perhaps some contemplated visit did not come off. The stela was bundled in between those of Khufu and Sahurê, and they and we all slept in Luxor that night.

DISCUSSION

Before the paper the PRESIDENT (Field-Marshal Sir PHILIP CHETWODE) said: We are this evening going to listen to a paper by Mr. G. W. Murray on "The road to Chephren's quarries in the Libyan Desert." Mr. Murray is now Director of the Topographical Survey of Egypt. He was previously Director of the Desert Surveys and has made many journeys in the western and eastern deserts of Egypt and in Sinai. Incidentally, during the Great War he was attached to the Desert Corps which I then commanded. Therefore he knows all there is to be known about the desert. For his work in exploring and mapping these areas Mr. Murray received the Gold Medal of the Royal Geographical Society in 1936. He has also contributed to research in these regions, very largely by the cordial way in which he has assisted other expeditions.

Mr. Murray then read the paper printed above, and a discussion followed.

Mr. OLIVER H. MYERS: There has been so much of interest and importance in what Mr. Murray has had to tell us, and he has discussed and added to so many different subjects, that it is difficult to make any immediate comment Moreover he has touched upon much which is of particular interest in connection with the period and the problems which I am studying; for instance the final desiccation of the Sahara; where the people went to, and how they impinged on the history of neighbouring countries; the various ancient routes in the desert and their dried-up wells and semi-desiccated oases. There are however two points I would like to mention. Count Almásy has pointed out a possible reference to 'Uweinat in the 'Arabian nights.' At 'Uweinat there is more than one wadi called Kurkur, the same name as that of an oasis near the Nile mentioned by the lecturer. In the 'Arabian nights' an expedition sets out from Upper Egypt to a mountain where black people live in caves, and this place is called Kurkur, which certainly sounds like a reference to 'Uweinat. But unfortunately in the story the mountain is beside the sea of Kurkur and anywhere farther from the sea than 'Uweinat it would be hard to find.

Mr. Murray mentioned the pleasure of travelling on roads which had apparently been abandoned since the Twelfth Dynasty, and this is certainly one of the charms of the desert. Sometimes however nasty shocks await the traveller. Mr. McEuen told me that when crossing the great sand sheet, the most aban-

doned and desolate part of the whole desert, he found, right in the centre, a pair of medieval Persian scissors, though it had been thought that no one had crossed there since the Neolithic period at the latest.

I feel sure that the exploration being carried out by Mr. Murray and others in the western desert will lead to important discoveries about the origins of Egyptian culture and its development during the Old Kingdom.

Major R. A. BAGNOLD: I cannot say that I have been to the areas about which Mr. Murray has spoken. We heard about Chephren's quarries in 1931, but failed to find them in 1932 on our way home from the Sudan. About 20 miles south-west of the quarries we did however pass a large area of neolithic implements and bones. Farther north, too, between Armant and Kharga, we found neolithic sites in 1938. It is clear that the limestone plateau west of the Nile was occupied in early days.

I was much impressed last year at Armant, when staying with Mr. Myers, to see what I did not think ever happened in Upper Egypt: the clouds were right down over the plateau west of Luxor, just like the thick mist one sees on the Scottish Highlands. I understand that in certain years there is sufficient rain even as far south as this to support a thin crop, which shows that even now that part of the Libyan Desert is not quite dead. It only needs a small amount of extra rainfall to produce a good deal more permanent vegetation.

H.E. The EGYPTIAN AMBASSADOR: I have not travelled in the part of the country described to-night, although I am an Egyptian. I should however like to ask the lecturer if the name Darb el Arba'in implies a forty days' journey. Does it take forty days to go from the Sudan to Asyut? We have in Egypt streets with the name Arba'in, which means forty. We have also small shaikhs called Arba'in, and there are many other Arba'ins all over Egypt which have nothing to do with forty days or forty as a number in itself.

The second small point concerns the use of the road by the ancient Egyptians. The lecturer thought it probably not used, but he was not quite sure because at that time the Egyptians did not know of the existence of camels, and such distances as 105 miles or even 50 miles from well to well would not be covered by a donkey. If we accept that supposition we must suppose also that at that time the climate of that part of the country was the same as it is to-day. If, as Major Bagnold has implied, there was then a little more rain than now, travellers could easily have gone from one place to another, especially when, as the lecturer has said, the water-level was not very far below the surface. We see to-day that even the Badawin do not go on riding camels when they are going to pasturage. They take all their cattle into the desert and cover longer distances than 100 miles at a stretch, relying upon the water they can dig for in the sand itself. For that reason it is difficult to say definitely that this road was not used by the ancient Egyptians. Between Aswan and Asyut the Nile during certain periods of the year overflows. This makes travel near the river extremely difficult and the roads become tortuous and uneven. It leads me to think that even in the time of the ancient Egyptians and now, in the case of the Badawin, the travellers prefer to take the straight road in the desert, that road which is known as the Darb el Arba'in.

Mr. MURRAY: His Excellency has raised a new point. Up till now we have always thought the road was called Darb el Arba'in because it took about forty days to get there from El Fasher. It is quite true that all over Egypt there are places called el Arba'in; they are supposed to refer to the Sahaba, and it might well be that the road has some connection with the legendary Companions of the Prophet.

As to the climate, I do not think there can have been a different climate in Twelfth Dynasty times, but I am open to conviction.

The PRESIDENT: It is somewhat striking to think that such an extraordinary civilization existed practically two thousand years before we were even heard of in these islands. It is extraordinary to see such a photograph as that of the statue shown this evening, representing a high degree of attainment in art and a man of high breeding and distinction. It is strange that we in the year 1939 can get no further than the monstrosity recently illustrated in the press.

Everybody who knows Egypt knows that the western desert is for the most part hard. It is possible to motor over it with some degree of comfort. But I was in command of what is known as the Desert Corps in the eastern desert, and there one could not go out of a walk on a horse; the sand was so heavy that it was similar to that found above tide-level on the coast of this country. I have never quite understood why the difference in the type of sand is so abrupt.

Another question in regard to which I have never yet received a satisfactory answer concerns water. I see General Sir Guy Dawnay here, who was at one time my Chief of Staff. He and I know very well how easily we found water in the eastern desert. We walked along the beach just as Napoleon did and actually, in places where in a storm the waves came over the sand, when we dug a few feet we found plenty of fresh water. Inland we found fresh water a few feet down. Where does that water come from in the part of the desert to which the lecturer alluded? We know perfectly well that there has been no rainfall, as we understand rainfall, in that part of the world for many years.

I went through the Suez Canal first in 1889, and we actually had a shower of rain as we passed through the canal. The commander of the transport had never even heard of rain in the canal. Since then, although there has been a little heavy rain in Egypt, there has not been enough to supply the amount of water there appears to be underground, unless it comes by seepage or soakage from the Nile.

Then Mr. Murray showed us an interesting photograph of a small circular stone wall which surrounded some rock on the top of a mound, and he said he did not know what it was for. There are probably in this hall many who have been in India, and it is not unlikely that there at once occurred to them the word *sangar*. It seemed obviously a defensive measure put up by some unfortunate soldiers told off for picket at night.

Before asking the lecturer to reply to these questions I would like to say how very honoured we are by the presence of H.E. the Egyptian Ambassador. Egypt has always been a country of the most intense interest. It is one of the cradles of civilization and it has always been one of the key-points of the world strategically. I would like to say how tremendously fortunate we are to have the King of Egypt and the Egyptian Government as great friends who are working with us at the present moment.

Mr. MURRAY: As to where the water comes from, a great quantity escapes from the Nile in the Sudan, and that is not all accounted for by the irrigation experts. Also the water may come from rainfall in some region of Central Africa. Dr. John Ball put forward a theory as to the approximate levels at which water might be found, and until now whenever we have bored wells we have found water at the approximate level he has given. Whether it comes from the Nile or Central Africa we cannot say. When it gets down to the Mediterranean areas it comes out at sea-level. We found in north Sinai that the wells of which the President spoke were always at sea-level. That was known as long ago as the time of Julius Caesar. When he was in Alexandria, having been defeated in a battle with the local Greeks, he took refuge near

Pharos, and the only water supply he had was a small canal. The Greeks at once set up a water-wheel to pump sea-water into the canal, with a view to annoying Caesar. Caesar told his men that it was well known that water occurred everywhere round the Mediterranean at sea-level, and that they only had to dig in the sand to find it. They dug in the sand and found water.

As to the difficult sand areas in Egypt, they exist of course in north Sinai, but people who are running a military expedition always apparently select difficult country. We had the most poisonous piece of country to go through in 1916. If we had gone farther south we could have escaped it. In the west there is plenty of difficult sand between Siwa and the Gilf Kebir. Nowadays we use very large tyres, larger than balloon tyres, and find the sand is no longer such an obstacle as it once was. As to why difficult sand occurs in one area and not in another I cannot say.

The PRESIDENT: I have now only to close the proceedings by asking you to accord the hearty vote of thanks which I am sure the lecturer deserves.

May I just take up a moment or two to tell you of an interesting fact? When the Desert Corps cut across the eastern desert of Sinai about 90 miles from the canal we came to El Arish, and I asked my expert where we were to dig for water. He said, "In the wadi you will go through blown sand, through gravel, and you will come into Nile mud." I expressed my doubts, but sure enough he was right. He pointed out to me that I should have known that to be so if I had known my Bible, for in it El Arish is called the River of Egypt. It is one of the old branches of the Nile although more than 100 miles away from the present river. We went farther to Gaza, and when we came to the Wadi Ghazza I said, "I suppose we are to dig in the wadi again?" and my expert said, "No. The water here comes from the mountains of Judea 40 miles' distance along a line of impermeable limestone." I again expressed my doubt, but a few weeks later we saw a thunderstorm going on up in the mountains of Judea, and sure enough the level in the Wadi Ghazza rose again. Once more he was right.

THE IMPERIAL COLLEGE EXPEDITION TO JAN MAYEN ISLAND

ALEXANDER KING

Evening Meeting of the Society, 24 April 1939

THE island of Jan Mayen is situated in the Greenland Sea some 250 miles east of the Liverpool Coast of Greenland and 300 miles north of Iceland. A summary of the history of the island was delivered to the Society by Mr. J. M. Wordie in 1921 and published in the *Journal* for March 1922. For a fuller historical account reference should be made to an article in the *Norsk Geografisk Tidsskrift*, 2 (1928–29), 411–44, which contains also a very full bibliography. It may nevertheless be of interest to outline some of the more important events which have taken place on this island.

It has been suggested that Jan Mayen was known to the ancient Norsemen and visited by them on their journeys to and from Greenland, being named Svalbard (cold coast), a name now generally applied to Spitsbergen. The evidence on this point is rather obscure, but considering the relatively short distance between Jan Mayen and the north of Iceland and the fact that the Beerenberg, the dominating feature of the former, is visible more than 100 miles off at sea, it seems not improbable. With the decline of Norway in the fourteenth century, the existence of Jan Mayen was forgotten and it was not until the beginning of the seventeenth century, when the Dutch and English were rivals in the arctic whaling-grounds, that it was rediscovered. The discovery was probably made independently by several ships, but for economic reasons the secret of the island's existence was guarded. Several names have therefore been put forward for the discoverer of Jan Mayen, the most famous being that of Hudson, but credit is now generally given to Jan Jacobsz May, who landed there in the year 1614 and after whom the island is named. In the same year at least one other Dutch captain, Kerckhoff, visited it and thought his discovery new, while in 1615 Robert Fotherby went ashore. Fotherby, who refers to it as Sir Thomas Smith's Island, wrote a pleasing and very accurate description of the place, recording his observations of the tracks of foxes and bears, noting the crystals of olivine shining in the sand like grains of yellow corn, and naming its volcano Mount Hakluyt, which name has thus precedence over the present Beerenberg.

The importance of Jan Mayen to the whalers was soon recognized. A Dutch company erected vats on the shore for boiling down blubber, the first being in Mary Muss Bay,[1] while others were later built in South Bay, in Seven Hollander Bay near the Rooberg, in Great Wood Bay, in English Bay, and in East and West Cross bays. The chief centre of this thriving whaling station was in English Bay, where there were ten huts. Some remains of the Dutch factory are to be seen near Walrus Gat, the bricks still well preserved, while skeletons of whales (Greenland, blue, and bottle-nosed) are half

[1] Mary Muss was an energetic matron of Amsterdam who, seeing the economic possibilities of Jan Mayen, sent out the first blubber-boiling equipment to be established in the bay which still bears her name.

buried in the sand in several places. Some idea of the importance of the station will also be gained from the fact that in 1618 nineteen Dutch ships were working off Jan Mayen; in 1617 one ship brought back to Holland as much as 4000 barrels of oil. Meanwhile, in spite of Dutch industry, other countries were not unaware of this important island. Thus in 1618 James I graciously granted a monopoly to a Hull Company to whale at what was then in England known as Trinity Island, while as late as 1630 Richelieu, in the name of the King of France, gave a licence to a French company to work off the Isle de Richelieu. The Dutch name of the island was at the time Mauritius (the name given by Kerckhoff) or St. Maurice, in honour of Prince Maurice of Nassau.

Normally Jan Mayen was evacuated on August 28 each year, but in 1632 the Dutch possessions were plundered by Basque pirates, and so it was decided to leave a wintering party during 1633–34. Accordingly a party of seven men were left on the island, but all perished of scurvy before the spring. A cross to the memory of these Dutchmen was erected by the Austrian expedition of 1882 in Seven Hollander Bay, but a Dutch cemetery was later found near the main station at Walrus Gat and the remains discovered probably include those of the seven unfortunate guardians whose memory is now perpetuated by a stone erected there by the Dutch Government in 1930.

With the decay of whaling in the Arctic, Jan Mayen became once more deserted in 1642 and was visited only by a few curious travellers who reported volcanic eruptions or brought back fantastic accounts of the shape and size of the Beerenberg. The most famous of these visits is recorded by Lord Dufferin in 'Letters from high latitudes.'

In the year 1921 Jan Mayen's history entered a new phase with the establishment of a wireless and meteorological station by the Norwegian Government. Norwegian sovereignty was proclaimed in 1929. By filling a blank spot on the world's weather maps, Jan Mayen's isolation has thus again become important. It is unlikely that the island will be of use for any other purpose since, unlike Spitsbergen, its rival of the old whaling days, it possesses no coal or other economic minerals, no agriculture is possible, and, as a Norwegian commission has verified, there are no harbours. Several small parties have visited the island at various times during the present century for the purpose of hunting the arctic fox, the only mammal found on Jan Mayen with the exception of an occasional bear stranded by the recession of the ice. Some of these expeditions have been very remunerative, as will be seen from the results collected in the table opposite.

The hunting of foxes on Jan Mayen is now strictly controlled by the Norwegian Government. The staff of the wireless station are allowed to bring back a few animals or skins each year, and Mr. Birger Jacobsen, who owns the larger part of the island, occasionally obtains permission to send out a party to bring back a limited number of animals. During the 1938 expedition we saw large numbers of foxes, especially near the north end of Jan Mayen, and it is probable that the fox population, living on the fulmar petrels whose large numbers form an inexhaustible larder, has increased considerably during the last decade.

	Organizer	*No. in party*	*Result*	*Value*
1906	J. Gjaever, Tromsø	3	200–300 foxes 1 bear	30,000 Kr.
1908–9	L. Haugen, Tromsø	6	120 foxes	18,000
1910–11	do.	3	40–50 foxes	6,000
1917–18	J. Hagerup, Tromsø	4	242 blue foxes 20 white foxes 3 bears	110,000
1925–26	Meteorological station Jan Mayen	3	46 blue foxes 2 white foxes	15,000
1926–27	do.	4	14 blue foxes 5 white foxes	6,600
1926–27	Polarfront Co., Canada	4	19 blue foxes 1 white fox	10,000
1926–27	K. Hoel, Aalesund	3	10 blue foxes 1 white fox	2,600

Scientific expeditions to Jan Mayen

Jan Mayen is of considerable scientific interest on account of its isolated position, its geologically recent origin, and the Beerenberg. It is surprising therefore that it has not attracted more attention. Perhaps its size has discouraged prospective investigators and sent them to farther and larger fields.

The first scientific investigation of Jan Mayen was made by an Austrian wintering party during the Polar Year 1882–83. The work of this expedition was mainly magnetic and meteorological, but small biological and geological collections were brought back and a map was constructed which for many years had the reputation of being the most detailed map of any arctic region, and which has only received a few minor corrections from later explorers. We found this map satisfactory only in the central region of the island in the neighbourhood of the old Austrian station; the position and height of the Beerenberg as given by the Austrians is erroneous, and at the extremities of the island the coast-line is incorrectly drawn, while the details are mere feats of imaginative draughtsmanship. Another small Austrian party, consisting of three people, carried out magnetic measurements on Jan Mayen during the Polar Year 1932–33.

In 1921 Mr. J. M. Wordie led a party to Jan Mayen. Although prevented by transport difficulties from having more than a month ashore, this party succeeded in climbing the Beerenberg, brought back useful natural history collections, and made a general geological survey. Other biological work on Jan Mayen was carried out by C. G. and E. G. Bird during a summer expedition in 1934.

The 1938 expedition

Mr. Wordie was strongly of the opinion that another expedition should be sent to Jan Mayen to continue the scientific investigations which his party had so successfully commenced, and to explore the unknown parts of the island. Sufficient funds being available in 1938, a party of scientists from the Imperial College left London on June 25. The expedition was the first sent out from the University of London.

I was very fortunate in having with me Dr. R. Scott Russell, who was not only a competent botanist but a climber of some distinction; as assistants he had D. F. Westwood and P. S. Wellington, since botanical work was to form a large part of our programme. Our geologist, D. F. Ashby, planned to work in cooperation with W. H. Ward, our surveyor. J. M. Willcox, of the Middlesex Hospital, was our doctor, and also undertook ornithological work with O. R. Seligman. Other members of the expedition were J. N. Jennings (glaciologist) and S. R. Nutman (marine biologist). By taking such a large party we hoped to be able to make a comprehensive survey of the features of interest on Jan Mayen during the short arctic summer.

At Tromsø we boarded our expedition ship, *Fortuna*, a 150-ton sealer of uncertain age but high reputation, and were brought to Jan Mayen by favourable winds in four and a half days. Our first sight of the Beerenberg was not unlike Lord Dufferin's impressionistic vision, except that the summit of the mountain appeared dazzlingly white in a blue sky, the rest of the island being concealed behind a lambent mist. We carried with us the new Norwegian wireless operators, who are relieved once a year, and so we cast anchor in Jameson Bay in the central part of Jan Mayen, near the wireless station. Calm weather favoured the landing of our goods, which was difficult enough on the steep beach of volcanic sand, completely lacking in any sort of shelter. A base camp was quickly established beside a large patch of melting snow which served as our water supply. Water is one of the problems of life on this wet but excessively porous island. We transformed an Austrian magnetic hut into a laboratory. Packing cases made excellent benches and shelves; calor gas was used for heating, and within a few days it was possible to carry out normal scientific work on Jan Mayen with reasonable accuracy. This was essential for the soil analyses and many of the plant-physiology investigations. A few days later a botany camp was established in Fishburn valley, one of the few fertile spots situated just beyond the South glacier. A sealing hut at North Lagoon on the other side of Jan Mayen was also much used during the latter half of our visit.

Jan Mayen is about 35 miles long and, though all volcanic, is divided into three distinct parts. The central region where the wireless station is situated is in one place as narrow as 2 miles and consists of many large lava flows and volcanic sand deserts; there is practically no vegetation. There are a number of long beaches of dark volcanic sand mixed with shining crystals of olivine and strewn with driftwood from the great rivers of northern Siberia. In this region are the three lagoons, fresh-water lakes, separated from the sea by narrow sand bars. North Lagoon is relatively deep and has an approximately constant level. South Lagoon was very shallow in 1938, the south-west end being dry. The smaller, Ullerengs Lagoon, on the other hand, although varying somewhat in extent from week to week, had plenty of water throughout the summer and is a favourite resort of waders and other birds.

Within a mile of the wireless station Egg Bluff rises 500 feet sheer from the sea. On the top of this prominent cliff there are a series of steam-blows to remind one of the island's volcanic past, and there are others on Cape Traill in the south. During the earthquakes of the autumn of 1935 large portions of Egg Bluff fell into the sea, and further areas are ripe for the same fate.

The southern portion of Jan Mayen, to which we made several expeditions, is seldom free from mists for more than a few hours at a time, and even when clear is a dark forbidding country, devoid of all colour. It consists of a mass of irregularly placed peaks and volcanic craters of rugged outline, rising to nearly 3000 feet. In most places it falls steeply into the sea, although there are a few accessible bays, especially on the south-west coast. Here, as throughout the island, there are frequent cliff-falls, the volcanic rock being everywhere unsafe. Transport over such country is excessively slow and exhausting, there being no regular valley systems; progress has to be made over innumerable loose screes which look like gigantic heaps of uncemented ashes.

The northern portion of Jan Mayen is, except for a small triangular piece of land at the north-eastern extremity, entirely occupied by the Beerenberg, its ice-field, and glaciers, most of which come right down to the sea. This mountain which rises 7680 feet from the sea is the most impressive feature of the island, dominating the view from practically every part. The most remarkable characteristic of the Beerenberg is its ice-filled crater, which our surveyor found to be over a mile in diameter and which forms the *névé* of the Weyprecht glacier. On the northern side of the crater there is a huge gash in the rim where the glacier, walled by sheer rock faces, descends by an almost continuous series of ice-falls to the sea. The highest peak of the mountain, which we propose to call Haakon Peak, in recognition of the Norwegian sovereignty of Jan Mayen, rises immediately to the west of Weyprecht, while facing it across the glacier is the second highest summit. For this latter peak we have proposed the name Hakluyt Peak, thus bringing back to the map the name originally given by Fotherby to the whole mountain. The crater rim, a serrated, horseshoe ridge rising sheer from the ice-filled basin and $2\frac{1}{2}$ miles long, connects these two peaks. The Beerenberg was first ascended by Professor P. L. Mercanton and Mr. J. M. Wordie during the 1921 expedition. Climbing parties of the Imperial College expedition, led by Scott Russell, ascended the high summit twice and the hitherto unclimbed Hakluyt Peak once. Seven members of the expedition took part in one or more of the climbs.

It was important that we should climb the Beerenberg soon after our arrival on Jan Mayen, as we had an apparatus for cosmic-ray investigation which had to be exposed on the summit for as long a time as possible. Accordingly the ascent was made on July 12–13 from the botany camp in the Fishburn valley near the South glacier. For a successful ascent calm weather is essential, and during our stay on Jan Mayen there were very few days in which conditions were at all favourable with the exception of those in which the climbs were actually made.

We left the camp at 7 p.m. on a grey evening, there being however reasonable visibility. After crossing the lateral moraine we reached the South glacier at a height of about 800 feet. The mountain was then in full view, the glacier leading gently up to a height of some 5000 feet, from which point steeper slopes led to the crater rim. The eastern part of the upper slopes looked forbidding, with two rock ribs capped by threatening shelves of ice, but to the west an easier ridge seemed to offer a satisfactory route. After a tedious march of several hours, up the glacier, we reached an outcrop

of rock beneath the steeper slopes and halted for a meal. Conditions on the upper part of the mountain were becoming progressively worse. A thick mist made route-finding difficult and snow conditions were bad. Great care had to be taken on the broken slopes owing to crevasses, dangerously hidden by soft snow. After an exhausting climb during which we frequently sank in the soft snow above the knees, we reached the rim of the crater. Thick clouds obscured the view, but through gaps could be seen the opposite side of the crater rim, while in the other direction the peaks of south Jan Mayen could be seen, sticking out of a sea of cloud. The climb along the narrow ridge to the summit was interesting, but when we reached the highest point, a rounded mound covered with coarse crystals of hoar frost, snow was falling. The cosmic-ray apparatus was deposited and we descended rapidly in worsening snow conditions to the top of the South glacier. After several adventures in the crevasses we reached the camp in heavy rain after a climb of eighteen hours.

To recover the cosmic-ray apparatus a party again ascended Haakon Peak, five weeks later. This time the ascent was made by a route well to the west of the bad crevasses of the South glacier. Starting from the base camp, the party ascended Ekerold valley, and traversing a heavy blanket of cloud which enveloped the lower slopes of the mountain emerged into the sunshine at a height of about 2500 feet. It was now late in the short arctic summer and the sun was below the horizon for a short time. Ideal snow conditions were encountered and advantage was taken of the clear conditions on the summit to photograph completely the great crater rim and basin. Altogether this ascent formed a pleasant contrast to that undertaken earlier in the season. We were fortunate in choosing this day for the climb, for, shortly after the return to the base camp the weather broke and heavy falls of new snow on the upper slopes of the Beerenberg made it unlikely that a further ascent would be possible that season.

In the interval between these two ascents we planned to visit the almost unknown north-eastern extremity of Jan Mayen, an expedition expected to last about a week, during which time we hoped to complete a circuit of the Beerenberg at a low level. Very little information was available as to the conditions which we should expect, since most of the country had not previously been traversed, except possibly by fox trappers. The map, based on observations from the sea, proved most unreliable. Our aims were very varied; glaciological, botanical, and ornithological records were to be made and a sketch-map prepared. We hoped to find Lord Dufferin's "wooden Ariadne," the figurehead so romantically left by him in 1854, mounted on a rocky promontory, with a biscuit tin tied round her neck. There was also the possibility that, if the weather proved favourable, we should attempt to climb the north-east peak of the Beerenberg (Hakluyt Peak).

Accordingly a party consisting of King, Russell, Jennings, Ward, and Seligman set out. The greater part of the coast-line consists of cliffs, sometimes as high as 2000 feet and nearly always unclimbable. Along the south coast progress was relatively easy above the cliffs, on gentle slopes which are the most richly vegetated part of the island. No such route was possible on the steeper east coast, but fortunately we found a gully of loose rock down which it was possible to scramble to the shore. We then followed the narrow

beach to the north-east end of the island. Going was easy here, except for a final climb over steep scree, perched rather precariously above the sea, but the threat of rock-falls made us hurry past the steeper cliffs. From the ice-edge, just visible beneath the clouds, many glaciers descended in ice-falls between the cliffs to the sea.

At Clandeboy Creek, a most inappropriately named bay which in no way resembles a creek, and which is wrongly placed in the Austrian map, we could find no trace of the figurehead. In all probability a rock-fall carried it away decades ago, although there is an unconfirmed rumour that it was removed by a trapper.

We reached the flatter country at the north-east of the island after fourteen hours' hard going, and spent the next day in examining this section in most unfavourable weather conditions. There seemed little prospect of immediate improvement in the weather, and a delay of more than two days would have produced a food shortage and the abandonment of the more strenuous part of the journey which lay in front of us. It was therefore decided that Russell and Jennings should attempt to complete the circuit of the mountain if the weather improved during the next week, and that the others should return to the base as quickly as possible so that the remaining food might be left for the climbers. This return journey was extremely unpleasant. We had to wade in the surf under the snouts of glaciers just about to calve, were seriously threatened by rock-falls and, after climbing the gully to the top of the cliffs, we were blanketed in a thick mist, through which we had to strike by compass over difficult country.

Russell and Jennings were fortunate in the weather and succeeded in climbing Hakluyt Peak. The main problem here was to find a way up the cliffs, but eventually a satisfactory route was found in a steep snow couloir 2 miles to the west of their camp. Above the cliffs, an ascent was made to an easy ridge commanding a fine view of the northern face, 5000 feet above; the Weyprecht glacier could be seen as it emerged from the crater and fell down to the sea in a vast ice-fall. Lower down the angle of the glacier was less steep, but everywhere the ice was fantastically distorted. From the snout of the glacier, washed by the sea, a flotilla of small icebergs drifted slowly with the tide. East of the upper ice-falls could be seen steep faces of rock, capped by the graceful conical summit of Hakluyt Peak. An easy ridge of broken rock and snow led to a steeper snow-slope below the summit. Across the great crater basin, bathed in sunlight, could be seen Haakon Peak, which we had previously ascended. After a pleasant and somewhat leisurely descent the climbers reached their camp in East Cross Bay after an absence of twenty hours.

The most difficult part of the circuit of the Beerenberg was still before them. Food was limited and it was important to cross the Weyprecht glacier in good weather. A few hours after the ascent of Hakluyt Peak the weather showed signs of breaking, so Russell and Jennings decided to push on at once although it was already late afternoon. By 10.30 p.m. the Weyprecht glacier was reached a few hundred feet above sea-level. The surface was very broken and much step-cutting was necessary. Frequent retreats had to be made, as the surface of the glacier was convex and only a short distance ahead

could be seen. An unexpected diversion occurred towards midnight, when they were nearing the western side of the glacier: a large liner appeared, passing slowly eastwards close to the shore. A few hours later, easy slopes beyond the glacier were reached and the tent pitched. Next day, after a long monotonous march, base camp was reached, where unexpected luxuries awaited the climbers, sent ashore by the cruising liner *Atlantis*, which they had seen on the previous day.

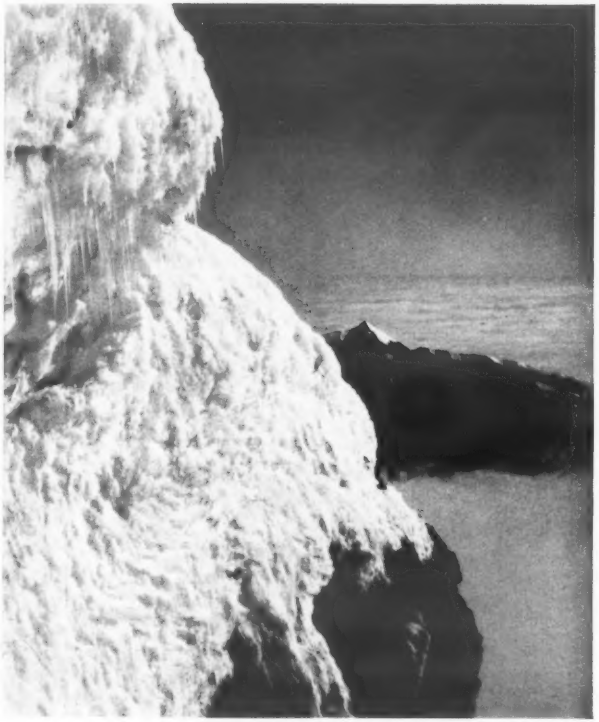
A word should be said about Jan Mayen weather. The wireless operators persuaded us that last summer had been exceptionally good according to island standards, and the fact that three ascents of the Beerenberg were accomplished probably supports this. Nevertheless conditions were such as to make life in camp very uncomfortable. During the last three weeks of July there was almost continuous mist at the base camp, broken only by fierce gales and heavy rain. The beginning of August saw some improvement in conditions, but a glimpse of the sun was always an exception. One night we went to bed in a thunderstorm of almost tropical violence and were wakened in the morning by an earthquake. Towards the end of August we had a hurricane of forty-eight hours' duration, during which our tents collapsed, their poles broken like matchsticks. Storms of volcanic sand are common on the eastern shores of Jan Mayen, ships several miles out at sea occasionally collecting inches of it on their decks. Volcanic sand becomes an inevitable constituent of each meal eaten on the island.

During the summer the wind was often from the south, and this caused a swell of such magnitude as to make landing impossible for a large part of the time. At the end of August, in order to embark on the *Polarbjørn*, the Norges Svalbard- og Ishavs- undersøkelser's ship returning from East Greenland, we had to carry all our apparatus and equipment weighing almost 2 tons some 5 miles to the sheltered side of the island.

Weather conditions on Jan Mayen are often very local. Thus during a hurricane at the base camp near the wireless station, which completely prevented work for two days, our surveyor was busy near the South glacier, a mere 3 miles away, in relatively calm weather. The south portion of the island is generally mistbound, but the north-west coast from Walrus Gat to North Lagoon has a much higher percentage of clear and calm weather than the opposite coast where we were generally encamped. Pleasant also is the absence of sandstorms in this region. The best general headquarters for an expedition on Jan Mayen would therefore be at the North Lagoon sealing hut or farther south at Haugen's Hut; at both these places there are ample supplies of fresh water. The old Austrian station in Wilczek valley is ruinous and leaves a melancholy impression. Some of the buildings have been completely demolished and used as firewood by trappers, while foxes inhabit the "basement" of the main hut, the floor of which is strewn with the remains of birds. On the hill-side a few yards away from the station are crosses which mark the graves of an Austrian sailor and of Norwegian trappers who have perished on the island; the coffins stick dismally out of the sand. This position does not recommend itself for a camp, in spite of its central position, as water has to be carried some distance from North Lagoon. Work on the north end of Jan Mayen is most conveniently carried out from a base in the excellent new hut

Hakluyt Peak from the north

The base camp



Rime formation on the crater rim, Beerenberg

in East Cross Bay, although water has to be carried some distance. Transport on Jan Mayen is a matter of great difficulty and should be carefully considered by future visitors. For carrying apparatus and supplies from one coast to the other in the central portion of the island (and this may be necessary owing to embarkation or disembarkation difficulties on one side or the other) some sort of light metal frame on wheels would be an advantage. A boat is invaluable, since much of the coast consists of unsurmountable cliffs. Some sort of mechanical propulsion is advisable and an outboard motor is to be recommended, as the boat should be light to allow of easy beaching in the heavy surf.

Scientific work of the expedition

By far the greatest part of our time on Jan Mayen was occupied in carrying out the scientific programme. As many of the results are not yet completely worked out, it is only possible here to give a general account.

Surveying. Weather conditions on Jan Mayen in the summer are little suited to the surveyor, and prevented our original survey programme from being carried out in full. Nevertheless many corrections were made to the map (see map following p. 126). Ward measured a base of 2516·2 feet behind Egg Bluff with a 150-foot steel tape. The height of the Beerenberg (Haakon Peak) was established as 7680 feet and the position of the crater was shown to be much nearer the end of the South glacier than the Austrian map indicates. The diameter of the crater is about a mile.

Previous workers have attempted to make a study of the South glacier, which is in obvious retreat, but have left no permanent measurements to enable the retreat to be measured. A detailed map of the end of the South glacier with its moraines was therefore made, and should be useful in future studies of this, Jan Mayen's most accessible glacier. In addition Ward made several local maps in connection with botanical and ornithological work.

Glaciology. Jennings made a general survey of the glaciers of Jan Mayen, and several not previously recorded have been described and named. Whereas the Weyprecht glacier is still very active, those on the east, and the South glacier in particular, are retreating rapidly. Detailed measurements were made on this latter glacier (see Appendix II below, p. 128).

Geology. D. F. Ashby made a detailed geological map on a 1 : 25,000 scale of the central part of the island from South glacier to Walrus Gat, the sequence of volcanic rock types and the structural relationships being established. Jan Mayen has apparently originated entirely by volcanic processes. Failure to find any evidence of glaciation apart from that at present in progress on the Beerenberg leads to the conclusion that the island has come into existence since the main glacial retreat.

A feature of some interest is the discovery of inclusions of crystalline rocks in some of the lavas and ashes. It is hoped that these will yield some information relating to the formation of the crystals.

Botany. The botanical programme embraced a wide field of investigation. Extensive collections of flowering plants, lichens, mosses, and fungi were made. Sixteen species of flowering plants not previously recorded on Jan Mayen have been brought back, while the lichens include one species new to science and a new variety. The collections have been lodged in the herbarium

of the British Museum. A detailed list will be published shortly. Almost every part of the island was visited by one or more of the botanists, thus making possible an ecological survey of the whole region.

A number of physiological investigations were undertaken to show the effects of various aspects of the arctic environment on plant metabolism. The effect of the continuous illumination of the arctic summer on the stomatal mechanism of leaves was studied by porometers especially constructed for field work. The results indicate that the stomata, while remaining continuously open, are nevertheless light-sensitive, being more widely open during periods of high light-intensity and partially closing when the light diminishes. Preliminary experiments on carbon assimilation were carried out.

A soil survey of the island was made, samples being taken from various representative habitats for chemical analysis and for the study of soil fauna and flora. Analysis for the essential nitrogen constituents was made on the island. Preliminary results show that there is a widespread nitrogen deficiency on Jan Mayen, there being a correlation between nitrogen supply and the density of vegetation.

Ornithology. A general survey of the bird population was made. Very large numbers of fulmar petrels, Brunnich guillemots, puffins, glaucous and kittiwake gulls, and little auks nest on the cliffs. Several species of migrant bird were noted for the first time on Jan Mayen. Studies were made of colonies of non-breeding gulls and of the nesting habits of the guillemots.

Marine biology. S. R. Nutman made a study of plankton variation with environmental factors. The fauna and flora of the shore were examined as well as those of the lagoons and of various small lakes in the interior.

Miscellaneous observations. Plates for the detection of cosmic rays were exposed on the summit of the Beerenberg for the duration of our stay on Jan Mayen. A further batch was left wedged in the snow on the summit, and it is hoped that they will be recovered and returned to us by some future mountaineers who reach the top of Haakon Peak. A number of fine copper wires are attached to the apparatus and spread in different directions to facilitate finding should the box still be in position. These plates are sealed inside a tin box to protect them from the damp and light; the box should on no account be opened by the finder.

Measurements of magnetic dip and the horizontal intensity of the earth's magnetic field were made.

A collection of insects was made.

The expedition was made possible by generous contributions from the administrators of the Leverhulme Research Fellowships and the Central Research Fund of the University of London. We are also greatly indebted to Mr. P. Thrane, of the Vaervarslingen for Nord-Norge, who arranged our journey out, and to Dr. Adolf Hoel, of Norges Svalbard- og Ishavs- undersøkelser, who arranged our return.

APPENDIX I: NEW PLACE-NAMES ON JAN MAYEN AND CORRECTIONS TO THE MAP

Sufficient major alterations were made by our surveyor to justify the drawing of a new map. These changes are nearly all confined to the northern portion of the island, the southern portion being essentially the same as the Austrian map, except for a few minor modifications, and therefore uncorrected.

Below is a list (A) of names which we proposed for prominent features on the island and which have now been adopted for official use on the Norwegian maps. The list (B) consists of questions raised by other investigators such as Mr. J. M. Wordie and Mr. E. G. Bird concerning names on Jan Mayen. (C) is a list of the huts at present on Jan Mayen, the names given being those in common use amongst the Norwegians.

LIST A: NEW NAMES

Peaks of the Beerenberg:

1. The high summit to be named HAAKON PEAK.
2. The north-east summit to be named HAKLUYT PEAK.
3. The south peak on the crater rim to be named MERCANTON PEAK.
4. The summit between Mercanton Peak and Haakon Peak to be named WORDIE PEAK.

Other features on the north of the island, starting anti-clockwise from the wireless station:

5. The sandy beach which extends from the end of the lava flow east of the station to the moraines of the South glacier, and which contains Ullerengs Lagoon (*v. infra*), might be appropriately termed LONG BEACH.
6. The bay which lies between the east moraine of the South glacier and Cape Fishburn we named FISHBURN BAY.
7. FISHBURN VALLEY. For purposes of description we have given this name to the valley which runs inland from behind Cape Fishburn. This valley, whose steep sides give some degree of protection from the strong winds, is the most richly vegetated place on Jan Mayen.
8. HOPE BAY. This name is applied to the well-defined bay which lies between Capes Fishburn and Hope.
9. FOTHERBY GLACIER. This name is given to a large glacier, not indicated in the Austrian map, which approaches within half a mile of the sea a little over a mile east of Cape Hope. There is a lake at the terminal moraine of this glacier, which is a favourite bird haunt.
10. CLANDEBOY CREEK. This name was originally given by Lord Dufferin to the bay where he landed to deposit his figurehead. The place thus named on the Austrian map in no way answers to Lord Dufferin's description and, since the Austrians did not visit this part of the island, making the observations on which the map is based from the sea, we feel that we are justified in moving the position of Clandeboy Creek south of Dufferin glacier. This new Clandeboy Creek answers exactly to the description in 'Letters from high latitudes.'
11. SIGURD GLACIER. This name applies to a small glacier reaching to the sea half a mile east of Dufferin glacier. Sigurd was the Icelandic companion of Dufferin on his voyage.
12. EAST WEYPRECHT GLACIER. The Weyprecht glacier divides into two arms, separated by a rock ridge, before flowing into the sea. The smaller, eastern arm is covered with debris and not easily visible from the sea. For

purposes of glaciological discussion it is advisable that the east arm should be separately designated.

13. JORIS GLACIER. This glacier reaches the sea close to North West Cape. Joris was the name of the mate on Jan May's ship. In early accounts the whole island is referred to as "Master Joris' Eyland" until the name of the captain more appropriately replaced that of the mate.

14. CHARCOT GLACIER. This glacier, which reaches the sea just north of Muyens Cape, is named after the French explorer who visited the island on several occasions for short periods and photographed the glaciers in this region from the sea.

15. KERCKHOFF GLACIER. The name of the Dutch captain who was at Jan Mayen island has been given to a large glacier whose terminal moraine is situated just behind West Cross Bay.

16. MERGANSER ROCK is a prominent rock which sticks out of the sea in South Bay.

17. LAKE TORNOE. From this lake, behind Scoresby Crater, the Tornoe river emerges and falls rapidly to North Lagoon.

LIST B: OTHER CORRECTIONS TO THE MAP

1. GREAT WOOD BAY. The first map of Jan Mayen was drawn by Joris Carolus in 1614, this bay being named Gouwenaers Bay. Later Dutch maps introduce the name Great Wood Bay, which also appears on Scoresby's map of 1820. The Austrians mistranslated this name as "Treibholzbucht," and this error was retained in later English translations as "Driftwood Bay." In the early nineteenth century, as shown on Scoresby's map, South Lagoon and the surrounding flat land were under the sea. The names "Great Wood Bay" and "Little Wood Bay" then referred to two bays lying respectively north and south of The Pillar (Säule).

2. BEAR GAT. We confirm the observation of Mr. Wordie and Mr. E. G. Bird that the small bottle-necked bay south of Cape Traill does not exist. The name Bear Gat has therefore been removed from the map. It has been suggested that changes in the coast-line account for the disappearance of this bay, but it seems unlikely that such a big change could have taken place here in fifty years.

3. EKEROLD VALLEY. This name, suggested by Mr. Wordie for the well-defined valley which leads inland from behind Jameson Bay, is placed on the map. Ekerold is the name of the engineer who was responsible for the erection of the Jan Mayen radio station in 1921.

4. ULLERENGS LAGOON. This lagoon, situated on Long Beach, some 2 miles east of the wireless station, appears to be permanent and has been known to the Norwegians by this name for some years, without however having appeared on any map.

5. WALRUS GAT, BRIELLE TOWER, THE WALRUS. Some confusion is evident here. Walrus Gat seems to apply correctly to the small indent at the north end of English Bay which provides one of the few anchorages of Jan Mayen. From the Austrian map it would appear that the high, rocky headland which shelters Walrus Gat on the north is termed Brielle Tower; in reality however this latter name applies only to a conspicuous pinnacle of rock lying off the main cliff. To avoid confusion we therefore propose to term the main headland the Walrus. The relationship between Brielle Tower and the Walrus is clearly shown in the photograph facing p. 116. E. G. Bird suggests changing the name Walrus Gat, which is in common use, to Walrus Gap. This seems to serve no useful purpose. The Dutch word "Gat" is a rather vague term, indicating a

JAN MAYEN ISLAND

From surveys by the Austrian Polar-Year Expedition 1882-83 and the Imperial College Expedition 1938

Scale 1 : 180000

1 0 1 2 3 4 Miles

1 0 1 2 3 4 5 6 Kilometres

Heights in metres

71°10'
8°
N.E. Cape
East Cross B.
Hagerup's Hut
Hohenlohe Cr.
Sars Cruter
Svend Foyn Gl.
Kjerulf Glacier
East Weyprecht Gl.
Weyprecht Glacier
N.W. Cape
Sigurd Gl.
Dufferin Gl.
Clandeboy Cove
Muyens Cape
Camp Anna
Charcot Gl.
Frost Glacier
Haakon Peak 2340
Wordie Pk.
Bylandt
Rheidt Cr.
Beerenberg
Grieg Gl.
Scott Cr.
Kerckhoff Gl.
Willy Gl.
West Cross Bay
Cross Cape
Palffy Crater
Peterson Gl.
Cape Neill
Foster Gl.
S.E. Cape
Little Sand B.
North Lagoon
Hut
Hockstetter Cr.
Tornoe R.
Tornoe L.
Scoresby Crater
Vogt Cr.
Ekroll Valley
South Glacier
Cape Hope
Hope Bay
Cape Fishburn
Fishburn B.
8°
71°
Wildberg
Esk Cr.
Mohnberg
Danielsen Cr.
Lerna Cr.
Ullerengs Lagoon
Radio Station
Long Beach
Lagoon
Jameson B.
Turn Bay
Egg Bluff
Wood Bay
8°
70°30'

sheet of water which may be either a narrow strait or a broad area of sea. Scoresby's map shows Bear Gat to be the passage between Pilot Boat Rock (Rock like a sail) and the land. The small bay referred to above appears first on the Austrian map, with the name "Bear Gat" removed to it.

6. NORTH CAPE, NORTH-WEST CAPE, MUYENS CAPE. The Austrian map erroneously names the two capes of the north-west coast Cape North-West and, a few miles north of it, Cape North. On the older maps these are named Muyens Cape and North-West Cape respectively. Since the Austrian error does not appear to have come into usage, we have adopted the older names on our map.

7. EAST CROSS BAY; WEST CROSS BAY. Once again the Austrian map is in error here. Early maps (see for example Scoresby, 'An account of the Arctic regions,' 1820, vol. 2, plate 6) show West Cross Cove to be the well-defined bay east of the Swend Foyn glacier, while East Cross Cove is a small bay 2 miles farther east of the other. The Austrian map terms the original West Cross Bay "East Cross Bay," and places West Cross Bay many miles farther south, beside Cross Cape. Since the Austrian mistake appears to have become common usage on Jan Mayen it is preferable to retain it. The small bay which was the East Cross Cove of the older maps is thus without a name now, but is of little importance.

LIST C: HUTS ON JAN MAYEN

1. JAN MAYEN RADIO. The wireless station is situated on the lava flow behind Jameson Bay. Apart from the main station there is a reserve station in case of accidents and also several subsidiary huts. In the neighbourhood there is also a good hut erected by the Austrian expedition of 1932–33, which we used as a laboratory.

2. AUSTRIAN STATION. This station, situated in Wilczek valley behind Mary Muss Bay, is ruinous but provides some shelter in an emergency.

3. NORTH LAGOON HUT. This is a very comfortable sealers' hut on the sand-bar between North Lagoon and the sea. It is in good condition and will hold about six men. In a sketch-map of the island by the Norges Svalbard- og Ishavs- undersøkelser showing the position of huts, the North Lagoon hut is named Joestingshuset while a smaller hut, Andersenhytta, is marked some few hundred yards to the north-east. There is in fact no second hut and the North Lagoon hut is sometimes called Andersenhytta by the Norwegians.

4. HAUGEN'S HUT (Haugenhytta) is 1½ miles east of the Walrus. This hut was named Camp Dobbel by E. G. Bird from an inscription he found in it during his occupation in 1934, but the name appears to be unknown on Jan Mayen.

5. CAMP MARGARETE is situated in Seven Hollander Bay.

6. SCHJELDERUP HUT in South Bay has been burnt.

7. CAMP HELENE is on the lava flow to the north of Cape Traill; it is very small.

8. CAMP ANNA is to the north of North-West Cape.

9. HAGERUP'S HUT in East Cross Bay is uninhabitable, but there is a newer hut a few hundred yards away which is clear of cliff-falls.

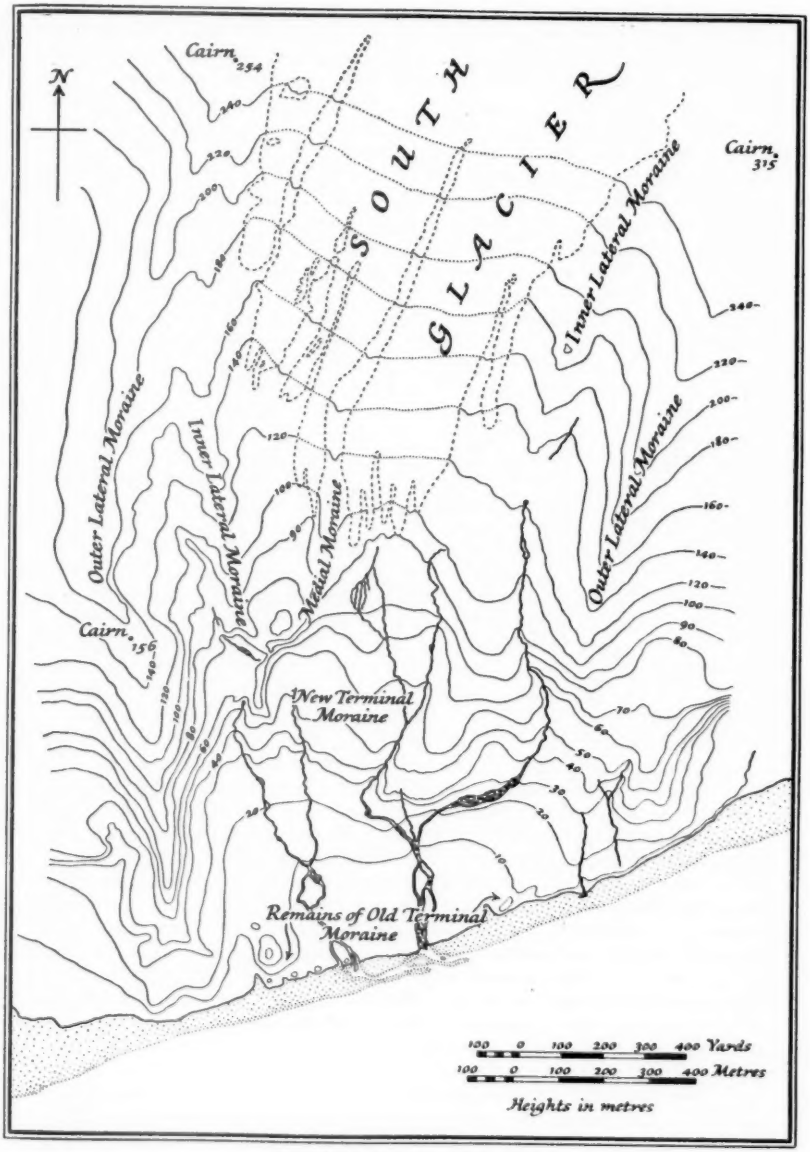
APPENDIX II : THE GLACIERS OF JAN MAYEN

J. N. JENNINGS

The glaciers of Jan Mayen are restricted to the Beerenberg, which forms the compact north-eastern portion of the island. There may be permanent snow-patches among the hills of the south-western plateau, but the altitude is not sufficient to give rise to glacierization proper. The Beerenberg consists of two superimposed cones: a broad, basal cone rises gradually to heights varying from 4500 to 5500 feet, above which rises the steeper inner one. The $2^{1}/_{2}$ miles of the horseshoe of the crater rim represents more than half of the original crater. The great breach of the crater rim on the northern side cannot be an erosional feature, but must have been blown away in the course of volcanic activity. The glaciers are radially arranged on the slopes of the Beerenberg, arising in shallow hollows or more fully developed corries cut into the inner cone. They present certain features characteristic of glaciers on volcanic cones. Instead of uniting and concentrating, they diverge and branch at the lower levels, as for instance the Swend Foyn and Kjerulf glaciers. Again, the glaciers from the Fotherby to the Kerckhoff occupy such shallow valleys that they appear to rest on the mountain slopes bounded by their moraine ridges, rather than to lie in valleys overlooked by rock walls. This is easy to understand if the glaciers did not inherit pre-glacial valleys as those of a normal mountain system do; and this may well be the case, since the relatively perfect volcanic form of the Beerenberg and the occurrence, at high levels on its ridges, of ropy lava in flows belonging to the general structure of the mountain point to a recent date for its formation. Glaciers most probably formed on its sides as soon as they were built up, for the Beerenberg cannot be earlier in age than Quaternary times. It is significant that the glaciers which occupy the most deeply incised valleys are the northerly running ones, which are at present the most active in the island.

It was expected that the mainly immature corries of the Beerenberg would yield further evidence on the problem of corrie erosion, especially of the importance of freeze-thaw processes, but the state of the ice above and below the corrie walls prevented work there. It is worth recording that melt-water was abundant at all levels and passed plentifully into the randkluft below the eastern wall at the head of the South glacier and into the bergschrunds inside the crater. The eastern side of the trunk of the South glacier offered better opportunities for study, and here freeze-thaw processes were of considerable importance. Water from snow melting on the low ridge overlooking the glacier ran under the *névé* banked up against that ridge. As the *névé* surface lowered through the summer, the lava cliff exposed was found to be shattered to a depth of several feet and as loose as an uncemented stone wall. The conditions in the crevasses inclined at an angle to the cliff approximated to W. D. Johnson's description of the bergschrund he descended. Blocks of rock in all degrees of detachment were to be seen in them, some bridging the gap from rock to ice, others entirely held in the ice. This lateral sapping of the glacier clearly much resembled the headwall recession of corries.

It was also intended to measure ablation and accumulation at different levels on the South glacier on the lines of Ahlmann's work, but the summer melt had advanced too far before our arrival to make this possible. Bamboo stakes however were fixed on the South glacier at intervals of 250 feet between roughly 1750 and 3500 feet. In the thirty-two days between July 10 and August 11, several of these stakes were washed out. The surface losses were all in the neighbourhood of 6 feet. This rapid loss agrees most nearly with the losses observed by Ahlmann at the lower level of 200 metres on Hoffellsjökull in Iceland. The



South glacier, Jan Mayen

most interesting feature of these observations was that no decrease of ablation with altitude through the vertical range of 1750 feet was detected. Pits were dug at the topmost stake to test the accuracy of such stakes as indicators of ablation, and by means of identifiable blue bands it was found to be quite high. The bands also gave an estimate of the net accumulation for the season 1936–37 as 44 inches of water. Since however blue bands have recently been shown to be impersistent and irregular in level, little reliance can be placed on such estimates. The alimentation of the glaciers of Jan Mayen is chiefly peculiar for the unusual importance of what Seligman has termed "arien deposits" at levels from about 5000 feet upwards. On the crater rim are many bulbous or mushroom-shaped masses, which are made up for the most part of rime. Other forms it assumes are vertical pendicles hanging from the peaks and ridges, and tongues or branches projecting inwards from the rim. Elsewhere the surface layers were extremely fibrous, being made up of large plates and branching flakes. The lack of any well-defined crystalline form pointed to rime rather than to hoar frost. Jan Mayen's oceanic situation in the zone of the polar front results in mists and strong winds of high humidity which promote the formation of rime. Previous estimates of the lower limit of glaciation have varied from 600 to 700 metres, but this appears to be too low, since the hills of the south-western plateau rising to 839 metres are not glacierized. In 1938 the summer snow-line on the southern slopes of the Beerenberg rose to about 900 metres (3000 feet). On the northern side the snow-line did not rise so high and was more in accord with earlier estimates.

Of necessity most attention was devoted to examining the features of the ice margin. The details of the glacier snouts cannot be given here, but the chief conclusions may be outlined. The physiographical features along the ice limits show that retreat has been going on for some time from what may be a position of maximum extent. All the glaciers, except the Swend Foyn and Kjerulf, yielded evidence of retreat, generally in the form of abandoned lateral and terminal moraines. But no horizontal retreat could be proved for the glaciers reaching the sea on the east coast; here a vertical decrease in thickness was indicated by the smoothed and cleaned rock surfaces of the valley walls to a considerable height above the glacier surface. Examination of the different types of moraine led to the conclusion that this retreat has had two phases. The earlier phase is represented by the extensive areas of hummocky moraine lying some distance in front of the Kerckhoff glacier and the glacier to the south of it; the moraines immediately west of the Weyprecht glacier also belong to this phase. The massiveness of these moraines implies most probably slow retreat when the glaciers were quite active. The second phase is indicated by the twofold sets of terminal and lateral moraines to be found at the ends of the South, Fotherby, Sigurd, and Joris glaciers, and also lying within the older moraine in the case of the Kerckhoff glacier. In all cases the twofold system was the same; high, outer laterals with a stable and fairly well vegetated surface enclosed lower ones which are unstable, enclose ice, and are not colonized by plants. The outer terminal has almost been removed entirely by the sea in the case of the South glacier. Between the formation of the two lines of moraines there was no accumulation of debris, pointing to a more rapid retreat of the glaciers and to a less active state than in the first phase of retreat. Some of the retreat of this second phase has occurred since 1882–83. Lieutenant von Boldva describes the ice of the South glacier as disappearing beneath its terminal moraine 80 metres from the sea. Now even the outermost part of the present terminal is about 250 yards from the shore. The Petersen and Dufferin glaciers do not now reach the sea, as the Austrian map of 1882 shows. The whole ice margin from the

Kerckhoff to the South glacier appears to lie behind its limits at the time of the Austrian mapping. Finally, there is evidence that the glaciers are still in retreat to-day; for instance, the Joris and Sigurd glaciers are abandoning their innermost moraines and are not building afresh.

It was stated above that the glaciers are retreating from their maximum extent as represented by their outermost moraines. This raises the question as to whether the island was generally glaciated in Quaternary times. There are many difficulties in the way of an answer: the relief features are of different ages (*i.e.* a fresh lava flow may bury such relics of a previous glaciation as moraines and smoothed rock floors), the island is so small that many features of glaciated scenery could not be developed, and the rocks involved are so weak that erosional features would soon be lost through rapid disintegration. An early impression however of the absence of any signs of general glaciation was strengthened later by a vain search for such evidence in the south of the island. This suggestion is put forward but tentatively, and it is hoped that future investigators will look into this interesting problem more thoroughly.

DISCUSSION

Before the paper the PRESIDENT (Field-Marshal Sir PHILIP CHETWODE) said: Mr. Alexander King is a lecturer at the Imperial College of Science, our near neighbour. With this expedition to Jan Mayen, organized by him and by Dr. Scott Russell, his college enters the field of polar exploration, and the two great universities of Oxford and Cambridge will have welcomed them as rivals in that field.

The first scientific account of the island was given by Captain Fotherby, the Elizabethan seaman, who named the great peak Mount Hakluyt. Scoresby landed there and gave an account of the volcanic phenomena. An Austrian expedition occupied the island for the Polar Year 1882–83, and made an attempt to climb the Beerenberg, which was first ascended in 1921 by Messrs. Wordie, Mercanton, and Lethbridge, who made collections. In that year the Norwegians established a wireless station, but it was left to this recent expedition to map the island. I now ask Mr. Alexander King to deliver his lecture.

Mr. King then read the paper printed above, and a discussion followed.

Dr. R. SCOTT RUSSELL: I am grateful for this opportunity of congratulating Mr. King not only on his paper but also on the way in which he led the expedition. The normal leader can rely on having at least half his party composed of experienced people; our party consisted almost entirely of men who had not hitherto undertaken any exploratory work. That was unavoidable in an expedition from a college which had organized no previous expedition. Therefore it seems to me to be a very definite achievement that the party was organized and kept in that cheerful frame of mind which is essential for successful scientific contemplation, especially as the expedition was carried on under particularly boring weather conditions, with a crowded base camp.

It has been suggested that you may be interested in the botanical work, but you will have gathered from the slides that plants are conspicuously absent from the greater part of the island; indeed, over the majority of slopes a few miserable mosses with occasional stunted flowering plants are all that occur. Here and there however, where there are special conditions of water supply and soil nutrients, there is more luxuriant vegetation. We found fifty-eight species of vascular plants which from our point of view were most interesting, although few of them would attract the Alpine gardener. The very scarcity of the vegetation and the unfavourable environmental conditions made the whole problem

of their growth particularly interesting, and we attempted some preliminary work to show how the various physiological processes by which plants live are affected by these rigorous conditions. Our comparative ease of transport enabled us to take the complex apparatus which you saw, and though on so short an expedition only preliminary work could be done, we have brought back results which will enable us in the future to undertake far more detailed investigation of these problems.

It is impossible to do the work necessary on this type of expedition without the advice of very many people, and it is only proper that I should emphasize to you the support and assistance that I received, both before and after the expedition, from a large number of distinguished botanists, especially Professor Gregory, at Imperial College, and Dr. Ramsbottom, Keeper of Botany at the British Museum, who both did everything possible to encourage the work, while two students from the Botany Department, P. S. Wellington and D. West wood, gave invaluable help in the field. In addition, a large number of gentlemen have worked on the material we brought back and advised us in the preparation of our results, among them Mr. Blackman, our long-suffering secretary.

It would not perhaps be out of place to say a word about the Beerenberg. I fear Mr. King has given you a rather exaggerated impression of the difficulty of achieving those climbs, probably because the first ascent of the mountain was made under particularly bad conditions and both he and I, quite accidentally, carried out rather intensive investigations in the depths of the South glacier. Later in the season conditions were better, and for the interest of the Alpine mountaineer I might suggest that to ascend the Beerenberg by the ordinary route is of somewhat greater length but about the same difficulty as, say, to walk up Monte Rosa, starting before breakfast from the Riffel Berg. In short, it is not a formidable climb. While we travelled fairly widely on the mountain we finished up with the conviction that both Mr. Wordie and Mr. Odell had selected the easiest and most climbable of routes when they made their ascents.

Hakluyt Peak is the more interesting of the two summits and, should any Fellow of the Society be passing Jan Mayen and desire a little fairly easy mountaineering, he would be far better advised to attempt Hakluyt Peak than Haakon Peak. The two climbs are about the same length, about twenty hours. As you will have gathered from Mr. King the great charm of the Beerenberg is the sudden view of the crater basin. In a way it is a far more dramatic and impressive view than anything I have seen in the Alps.

Mr. J. M. WORDIE: I should like, first, to say how much I have appreciated Mr. King's lecture and admired the way in which he organized an expedition with a personnel none of whom had previously been in the Arctic. The expedition was well planned and well led. The leader's lecture has stirred up memories. I was in Jan Mayen in 1921 and have forgotten much, but certainly not the bad weather which seems to prevail there. When Mr. King and Dr. Scott Russell told me that they were planning an expedition to Jan Mayen I can remember telling them that I thought they would find the weather conditions unattractive, which is perhaps putting it mildly, and that they should attack some other part of the Arctic. They went all the same, and that they did so much in spite of the weather drawback is a notable achievement.

One interest of Jan Mayen is that it is an island. For some reason or other people seem to like islands; perhaps there is a sense of completeness about an island. It was one of the things which I think attracted Mr. Chaworth Masters, who suggested our visit in 1921. There is a certain historic interest now in that expedition as it was the first of the Cambridge expeditions made after the War, and most of the party were undergraduates who had just completed their first

or second year's residence at Cambridge. It was the first of many, and marked a completely new phase of arctic exploration from this country.

Dr. Scott Russell has said that my party found the easiest way up the Beerenberg. I am glad that was the case because that is always the wish of any one making a pioneer ascent. What I remember particularly of that climb is the wonderful view from the summit ridge, when we suddenly came upon the great ice-filled crater forming the *névé* field of the Weyprecht glacier which flows from the crater through a huge gash in its rim and cascades down to the sea. I am particularly glad to know that the peak at the other tip of the horseshoe has also been climbed, and that it is to be given its original name of Hakluyt, as it was called by Fotherby, the Elizabethan seaman who wrote the first, and perhaps still the best, account of the island.

Mr. J. N. JENNINGS then gave an account of the glaciers of Jan Mayen, which has been incorporated in Appendix II printed above.

Mr. N. E. ODELL: I have been exceedingly interested in the expedition of the Imperial College to the Arctic, partly as a former member of the Imperial College and partly because I was associated with two of the first of these college and university expeditions to the Arctic, the Oxford Spitsbergen expeditions in 1921 and 1923.

My visit to this remarkable island of Jan Mayen took place early in July 1933 when I accompanied the North-East Greenland Expedition undertaken by Miss Louise Boyd. We landed for a few days, and Mr. Walter Wood, of the American Geographical Society, and I were fortunate enough to make the ascent of the Beerenberg, as you have already heard. A more striking and interesting mountain it would be hard to find, where present ice-streams appear in competition with ancient lava-flows.

We followed Mr. Wordie's route, but quite in ignorance of the fact, since we were travelling entirely in mist and saw nothing at all of where we were going or of the mountain itself, except for one brief five minutes when we were involved in a rather intricate ice-fall on the way up. I believe Mr. Wordie had no ice-fall in the course of his ascent, so we presumed we were at any rate on a variant of his route. Finally we ascended a buttress with a considerable amount of steep ice work, and reached the rim of the crater still enveloped in mist. We then worked our way along the pinnacled rim northwards until we came to a high icy eminence encrusted in heavy hoar, which we concluded might be the summit. We did not remain there very long, though we actually more or less settled down for a protracted stay, hoping to get a view of that wonderful expanse of *névé* in the crater basin. But to our great surprise and excitement, if not considerable annoyance, there was a loud crash and a flash and we almost thought we had been struck by lightning. We decided speedily to decamp from that very elevated and exposed portion of the crater. Thus I cannot say I had the view which is the great feature of the ascent of the Beerenberg.

As is so often the case with mountains in the early days of their exploration, the altitude of the Beerenberg seems to have somewhat deteriorated. The first Austrian Polar Year party made the height 8350 feet, Wordie considered it to be 8090 feet, and our corrected aneroid value for it was 7670 feet. The latter is a good approximation to the latest triangulation figure of the Imperial College expedition. The Admiralty Chart has only credited it with 6870 feet.

It seemed to me that there were indications of the glacierization of the Beerenberg being relatively recent, and I am interested in the suggestion that it is possibly entirely post-Pleistocene. It is an important conception for which there is being found some evidence in other glacierized regions. At the same time I feel it is premature to suppose that Jan Mayen had no Pleistocene ice covering at all:

future, perhaps excavational, work amongst the lava-beds must decide that. Some relation may eventually be established between conditions in this island and those in Iceland, where recent work by Jakob H. Lindal has revealed an unexpectedly varied Pleistocene succession with an interglacial formation (see *Proc. geol. Soc.*, No. 1361, 1939).

As far as the solid geology is concerned, the island is entirely volcanic. The nature of the lavas of the country has been already to some extent investigated from the collection made by Mr. Wordie and examined by Dr. Tyrrell, of Glasgow University. Incidentally, these lavas are known as trachyandesites and olivine basalts, and other basic lavas of which ankaramite is one notable type; indeed along the shores of Jan Mayen, and derived from the basic lavas, are to be found beaches composed almost entirely of olivine grains, something like the olivine-rich sands at Duntulm in Skye and among the islands with similar volcanic dyke formation in other parts of the Hebrides. The petrology of Jan Mayen deserves further study, apart from the glaciology, and a future expedition would do well to employ experienced specialists in these branches of science.

The PRESIDENT: I must confess that when I saw the subject for this evening announced I wondered what was there that could interest us in that little island in the Arctic miles from anywhere. But I am sure you will agree with me that Mr. King has, after all, made it most interesting. In fact I almost felt inclined to say: "Almost thou persuadest me to become an arctic explorer." I conclude by asking Mr. King how on earth foxes appeared on Jan Mayen, an island 100 miles from anywhere. I take it that they walked over when the sea was frozen; that they came originally from Greenland or somewhere near.

Mr. KING: They must have done so.

The PRESIDENT: I have nothing more to say except to ask you to pass in the usual manner a most enthusiastic vote of thanks to Mr. King and his colleagues for so thoroughly entertaining us this evening.

THE POLAR FRONT AND ITS PLACE IN MODERN METEOROLOGY

C. K. M. DOUGLAS

Afternoon Meeting of the Society, 17 April 1939

THE term "polar front" has been widely used in meteorology during the last twenty years, and it is undoubtedly a convenient general label for certain ideas which are well rooted in nature. Nevertheless it is often misunderstood and tends to be over-simplified in elementary text-books. The term was introduced by Professor V. Bjerknes, of Bergen, in 1919. The term "front" denotes a boundary between air masses of different properties, more especially as regards temperature, and fronts of one kind or another now occupy a fundamental place in weather forecasting, chiefly because continuous rain is normally associated with a front. The term "polar" in this connection denotes the boundary not of the polar regions themselves, but of air which is cold because it has come from the polar regions. The choice of the word "front" was probably influenced by the analogy of the fronts of the Great War. The notion of our weather changes being controlled by a struggle between tropical and polar currents has sometimes found favour, but this metaphor is of doubtful value, and at best is only applicable on certain occasions over limited areas.

The fundamental idea of polar-front meteorology is the sloping surface of discontinuity with cold air lying below warm air. This is the only type of surface of discontinuity which has sufficient stability to exist in the atmosphere, though its stability is only relative, and the development of cyclonic depressions on the fronts is in the nature of a breakdown of stability on a large scale, associated with the excessive shear between the adjacent wind currents. Helmholtz and Margules provided the foundation of the theory of atmospheric discontinuities, but Professor Bjerknes gave the impetus towards the great modern development of frontal meteorology, though it must be admitted that progress has been disappointing on the theoretical side, in spite of a great mass of published mathematical work. The main advance has been on the practical side, and J. Bjerknes, the son of V. Bjerknes, has played the leading part. His 1919 paper entitled "The structure of moving cyclones" has been well described by Colonel E. Gold [1] as "the most remarkable eight pages in the literature of synoptic meteorology" (*i.e.* the science of synchronous weather charts). Other notable papers on the subject have emanated from Norway, and nearly all the titles contain the word "cyclones." The cyclone (or depression) and the anticyclone still occupy a very important place in meteorology. The new ideas of fronts and air masses should be regarded as complementary to the older ones of cyclones and anticyclones rather than as replacing them. The cyclones and anticyclones are the systems into which air motion becomes organized, and the physical condition of a particular air mass and the associated weather may be determined in vital respects by the type of system in which it happens to become involved.

[1] E. Gold, "Fronts and occlusions," *Quart. J.R. met. Soc.* 61 (1935) 108–57.

Air masses

The idea of a mass of air is obviously required for the application of physics and dynamics to meteorology, but until some thirty years ago it entered little into the practical study of weather charts, which deal with phenomena with a horizontal scale of hundreds or thousands of miles. Upper air investigation has shown that the effective part of the atmosphere, where temperature decreases upwards and vertical circulation is possible, is limited to a layer some 5–10 miles in depth, known as the troposphere. Above this there is an isothermal layer or stratosphere, which has a stabilizing influence, but where little development is possible owing to the restriction on vertical circulation. Thus the horizontal dimensions of the major atmospheric systems are much greater than the vertical dimensions.

In 1906 Shaw and Lempfert published a classical memoir on 'The life history of surface air currents,' in which it was claimed that the air currents are at least as important as the associated cyclones and anticyclones. At that time this was a salutary warning against excessive concentration on the isobaric systems. The weather has only a moderate degree of correlation with the pressure systems, and in particular the continuous rain of depressions is generally limited to the regions where the air currents interact, as Shaw and Lempfert pointed out.

The idea of air masses is obviously involved in that of fronts, which are essentially air mass boundaries. A "discontinuity" of temperature, if subject to a microscopic analysis, is a region where the isotherms are crowded together, while away from the front they are far apart. The practical utility of air masses in synoptic meteorology depends very largely on the observed fact that temperature variation in the horizontal is often small over a large area. Sometimes there is remarkable homogeneity over an area which may reach a million square miles. These conditions arise when cyclones and anticyclones have grown to a large size, so that there are extensive currents between them. Frequently conditions are much more complex and large-scale air mass analysis is not always possible. Modern forecasting for aviation has to be detailed, and much of it depends on analysis of air masses of which the linear dimensions may be in tens, hundreds, or thousands of miles, according to the conditions. Much experience and discrimination are required for this work, and the same is true in connection with the large-scale problems with which we are here dealing. Though the fundamental ideas are simple, their practical application is far from easy, since most actual situations are complex. Oversimplification is inevitable in any presentation of the subject which is not excessively lengthy and involved.

A very important characteristic of air masses is that although the temperature and humidity of the air in contact with a land or sea surface are much influenced by that surface, in the upper air they are relatively conservative throughout a motion of many hundreds of miles. When one considers that a great mass of air can reach the British Isles from Spitsbergen, Baffin Bay, or from south-west of the Azores in forty-eight hours, it is not surprising that there should be great differences of upper air temperature, and obviously these are very important. In typical "westerly" conditions over the British Isles, *i.e.* with winds varying between S.W. and W. or N.W., temperature

fluctuations are much greater up aloft than near the ground, leaving out of account the diurnal variation, which only affects a very shallow layer. The approximate motion of the air at 2000 feet can be readily calculated from the isobars on a synoptic chart. To a first approximation the air above the surface frictional influence flows along the isobars at its level with a velocity inversely proportional to the distance between the isobars. The deviations from this approximate motion are of great dynamical importance, but do not affect the general conclusions as to the motion of large air masses.

In considering the classification of air masses it is important to note that there are no clearly defined categories which cover all the infinite variations of nature, but that a classification is imposed for practical convenience. In very complex conditions classification has little or no value. In regions such as Europe and the U.S.A. the increasing amount of upper air observations enables the meteorologist to deal directly with the physical properties of the air. Over the Atlantic the currents are clearly defined on the majority of days, and this also holds over the British Isles when the air streams are oceanic. The main categories are called "tropical" and "polar," depending on the source of the air and not on the direction of the wind at the time. The source of "tropical" air is between about 25° and 40° N., while that of "polar" air is the arctic regions, and in winter also the snow-covered areas of the continents. In summer the continents are warm, and the extension of the warmth up to nearly 70° N. is a complicating factor.

When warm air passes over a colder sea surface, low clouds or fog tend to form, and this is typical of maritime tropical air, but in summer the cloud often dissolves when it drifts inland. Cold air over a warmer sea surface gives cumulus clouds and showers. Polar air which has been much warmed over the warm waters of the Atlantic is called maritime polar air, when it reaches western Europe, to distinguish it from direct polar air from the north (often called arctic air) and continental polar air arriving from some easterly point. In the British Isles polar air is fully five times more frequent than tropical air, and the dominant type is maritime polar air.

A point about which there has been some discussion is the influence of the Gulf Stream on the climate of the British Isles. The main cause of our mild winters is undoubtedly the fact that we are on the east side of an ocean, but if there were no Gulf Stream the temperature of the Atlantic would be lower by a few degrees and maritime polar air would be colder by about the same amount. This would greatly add to the snowfall on all high ground, especially at heights between 500 and 2000 feet.

The life history of depressions

Modern air mass analysis is an inevitable development to which many countries have contributed, and much of it could have been developed independently in any of them. But there was a real stroke of genius in the Bergen works of 1919–20 which has profoundly influenced the course of meteorology, namely the following out of the life history of the cyclonic depression, and the sharp distinction made between the newly formed depression and the old depression. The latter are much the most frequent in western Europe, and have an entirely different structure from the new ones, the difference being

even greater in the upper air than at the earth's surface. The brief outline given below is similar in essentials to the account originally given by Bjerknes, though some later modifications are included. The first models were too much influenced by local conditions in Norway, and have been slavishly followed in many text-books, although better models were published in Norway only a few years later.

Fig. 1 shows the three main distributions of air currents at a front, (a) and (b) representing a stationary and (c) a moving front. Depressions may form

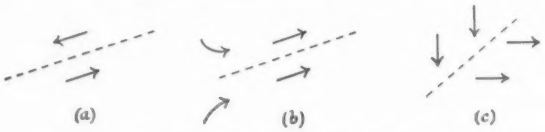


Fig. 1. Types of front, showing wind discontinuities

on any of them, but not at all readily on fast-moving fronts, so that it is simpler to consider a stationary front. The *relative* motion of the air currents at a front is always as in (a), and this is the simplest case to consider. It is a frequent condition off Florida and the American coast, where depressions most often form, whereas type (b) is the commonest type off our own coasts (see

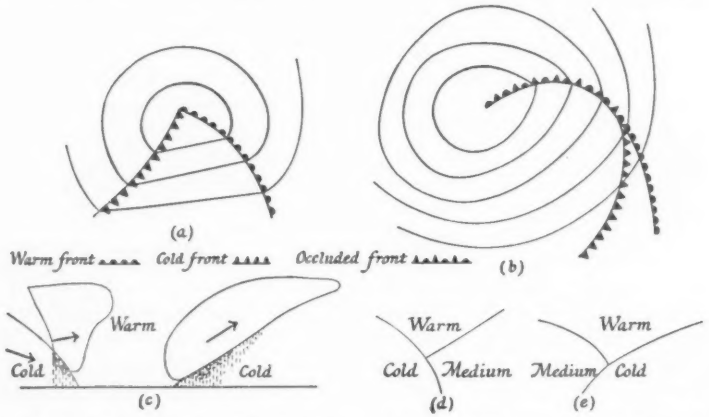


Fig. 2. (a) *Depression with warm sector;* (b) *occluded depression;* (c) *vertical section through warm sector;* (d) *and* (e) *vertical sections through occlusions*

Fig. 9). The diagrams may be turned in any direction and still represent conditions found in nature.

Fig. 2 illustrates the life history of a depression. The first stage is a slight bend in the front, which grows larger till it forms a definite "warm sector," bounded by a warm front (*i.e.* warm air advancing) and a cold front (cold air advancing). As the depression deepens the warm air rises and eventually leaves the ground, and the depression is then "occluded," as shown in the

diagram. The vertical sections illustrate what happens in the upper air. The ascent of the warm air over the cold, and its advance and lateral spreading in the upper currents, gives the well-known cloud sequence ahead of a depression, and where rain is falling there is a great thickness of cloud, mainly above but also below the surface of discontinuity. Most of this cloud is very tenuous, consisting of ice crystals in the high levels, so that the light is often quite good during rain. The slope of the warm front surface is of the order 1 in 100 to 1 in 150, and that of the cold front 1 in 50, though there are great variations. The rain-belt at the cold front is narrow, and the clouds are often, but not always, of cumulo-nimbus type. The surface of discontinuity is a simplification of the actual structure, and there is usually a transitional layer some thousands of feet thick, where the vertical temperature gradient (lapse rate) is small. Temperature "inversions" (*i.e.* increases with height) in the atmosphere are usually due to other causes, and confusion on this point has led to a good deal of wasted effort. After occlusion there is usually some difference of temperature between the air masses on the two sides, since though both are of polar origin their recent life history has been different. If the air behind is warmer, the vertical section is as in (e) of Fig. 2, and if it is colder it is as in (d). These diagrams are inevitably idealized.

Practical examples

Figs. 3 to 8 illustrate two typical depressions, though the very earliest stage is not included. Figs. 3 and 4 show a depression with a warm sector moving north-east over England and becoming occluded at the centre. Fig. 5 gives upper air observations at Mildenhall (Suffolk), Aldergrove (north-east Ireland), and Königsberg (East Prussia), and brings out the high upper air temperature of the warm sector. Above 20,000 feet the Mildenhall and Aldergrove curves converge, but a sounding farther west would certainly have shown cold air through the troposphere. The cold front was masked at the earth's surface, as far as temperature alone is concerned, and its position was based on wind and barometric changes. There is now a great mass of observations of upper air temperature which justify these methods of identifying fronts.

Figs. 6 to 8 illustrate the development of a very deep Atlantic depression which caused a heavy gale over the British Isles with gusts of 100 miles per hour at Pembroke. The charts are at uneven time intervals, their selection having been based on the number of observations from ships. (Where observations from ships are lacking on the Atlantic, isobars and fronts have to be interpolated; the whole sequence of charts is used for the interpolation.) Fig. 6 shows an old deep depression near the Faroes, with an occlusion which has spiralled round it, and a typical front in the westerly stream between tropical air and polar air from west of Greenland. Near the Straits of Dover there is a small disturbance or "wave" on the front, of a type which is often the earliest stage of a deep depression, though on this occasion the amount of subsequent development was only moderate, as the depression travelled quickly into the cold continent. Another depression near the Azores had already passed its first stage and had an ample supply of warm air. Nineteen hours later it had developed into a fully fledged cyclone, and pressure at the

centre had fallen by 40 mb. There was still a considerable difference of temperature between the air which had travelled round the trough and was moving from south-west and the northerly current behind the depression. Between them there is a secondary front, in this case called a "back-bent occlusion" owing to its method of formation. Twelve hours later the depression had changed its direction and moved eastwards to north-west Ireland

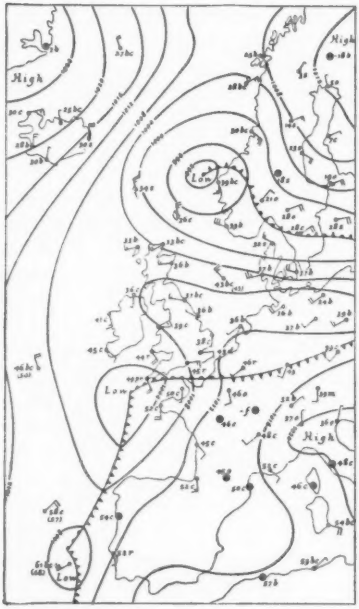


Fig. 3. Synoptic chart for 1800 on 10 January 1939

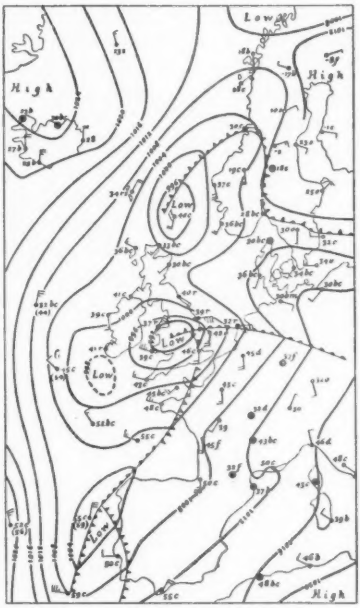


Fig. 4. Synoptic chart for 0700 on 11 January 1939

Isobars drawn at 4-mb. intervals. Temperatures in degrees Fahrenheit. Sea temperatures occasionally shown in italics to right of air temperature. Arrows fly with the wind. Each full feather denotes two figures on the Beaufort scale of wind force, and each small feather one figure, e.g. ıı. *indicates Force 5. Black dots indicate rain falling. Weather shown in Beaufort notation as follows :* b=*blue sky (not more than a quarter covered);* bc=*sky partly cloudy (about half covered);* c=*cloudy;* o=*overcast;* d=*drizzle;* r=*rain;* s=*snow;* rs=*sleet;* h=*hail;* p=*passing showers;* f=*fog;* m=*mist.*

and become still deeper, probably owing to the secondary front and also to instability in the vertical, due to the transfer of heat and moisture from the warm sea surface to the polar air mass, a point which will be discussed later. The severe gale occurred as the depression moved in over the British Isles, long after the passage of the warm sector, and this is true of most really severe gales.

Now that observations from ships have become relatively numerous,

examples of the development of deep depressions from warm sectors are frequent. There are however many complicated structures, and for an adequate study of the subject it is essential to follow a long series of weather charts showing fronts, such as the International Section of the Daily Weather Report of the Meteorological Office.

The causes of the formation of depressions and fronts

A typical depression in its earliest stage travels as a sinuosity along the

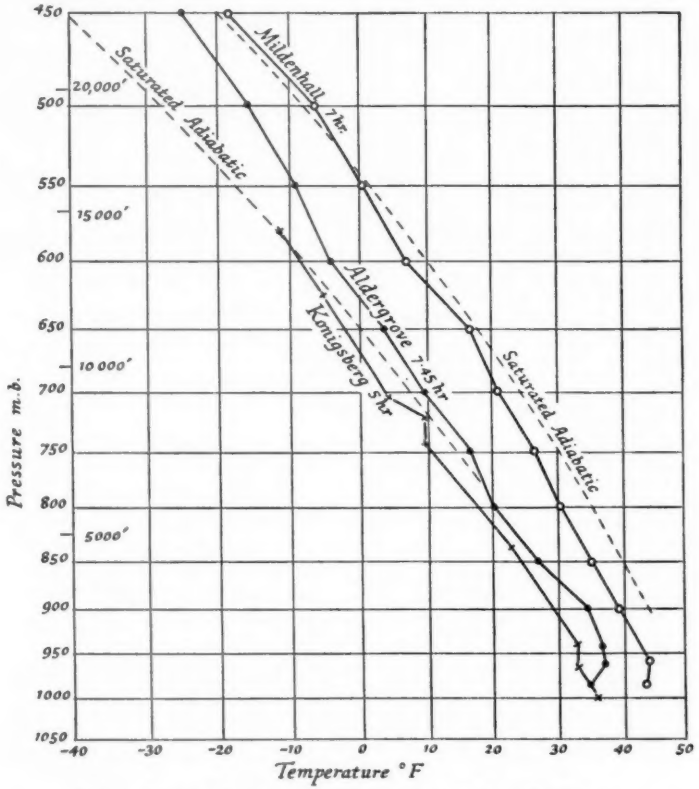


Fig. 5. Upper air temperatures on morning of 11 January 1939

front, resembling a wave, but there is no agreement among meteorologists as to whether it is a true wave on the surface of discontinuity. The depression travels with the warm air, but moves through the cold air, producing a wave-like disturbance in it. Some disturbances never pass this initial stage, but disappear after moving some distance along the front. For development into an intense system some type of instability is involved, depending both on the wind structure and on the distribution of temperature and moisture in three

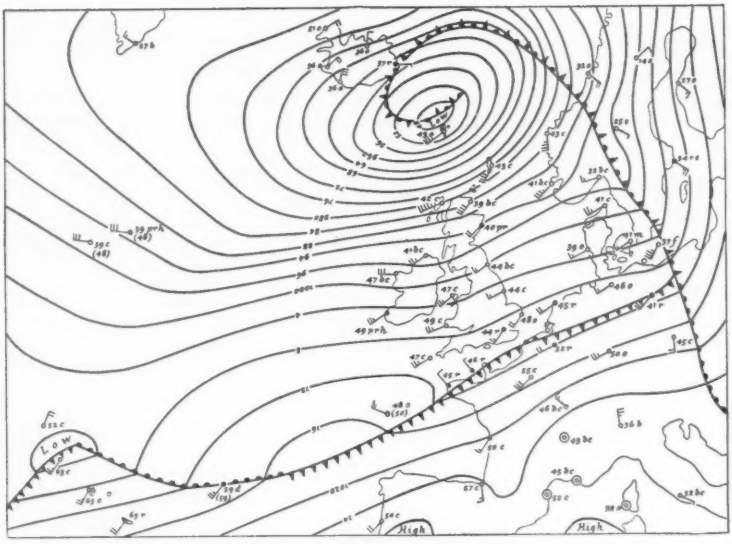


Fig. 6. Synoptic chart for 1800 on 13 January 1938

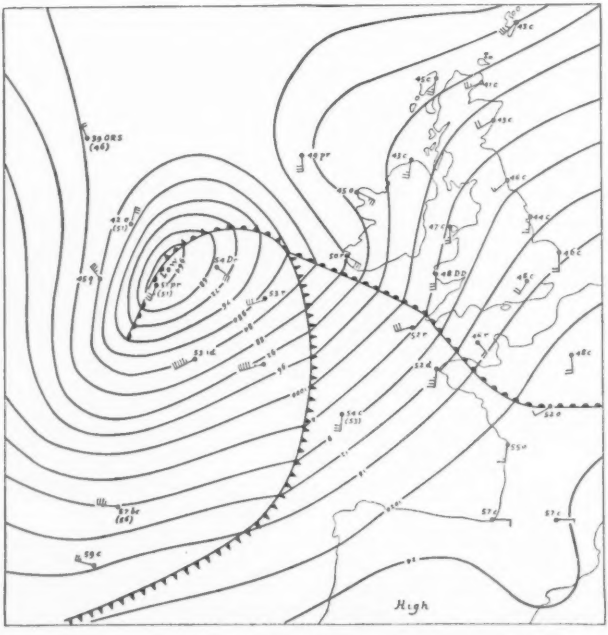


Fig. 7. Synoptic chart for 1300 on 14 January 1938

dimensions. It is the number of variables which make the problem so difficult, like other major meteorological problems. The fully developed depression is generally recognized to be of the nature of a rotary system or vortex, but even then there are often irregularities of structure. When there is a warm sector the actual low-pressure system is confined to a comparatively shallow layer, although the whole troposphere is involved in the disturbance of motion. In an old depression the troposphere is cold, and this means that

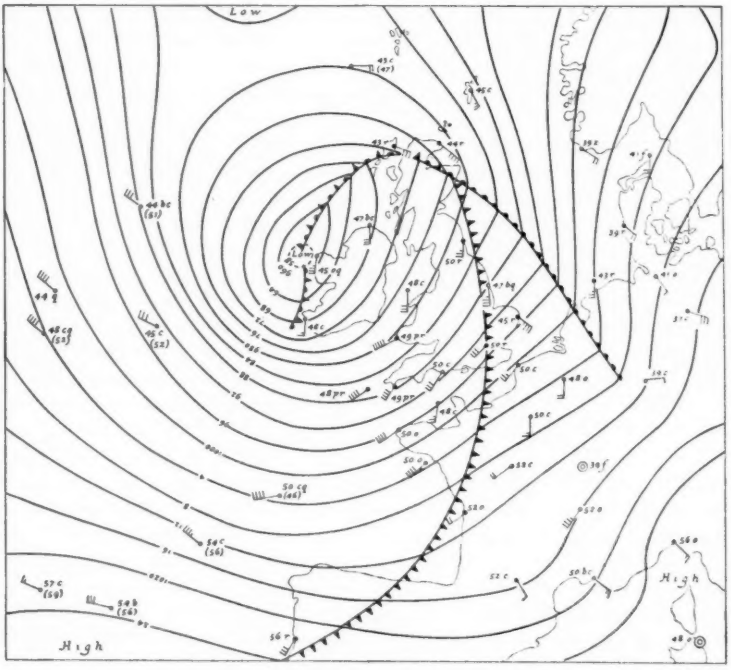


Fig. 8. Synoptic chart for 0100 on 15 January 1938

pressure is low in the upper troposphere, but only in some cases is it possible to detect an axis of rotation extending through the troposphere.

The more or less straight front preceding the development of a new depression is usually a trail left behind by an earlier depression, marking the southern limit of the cold air circulating round it (Fig. 6 is fairly typical). Thus a front is both a cause and a consequence of a depression. There is no circular reasoning here, so long as our ideas are based on the actual atmosphere and not on an imaginary atmosphere in a state of rest or of steady motion. Irregular motion must have been present in the atmosphere since its separation from the solid and liquid earth's surface. If the amount of irregular motion is weak, the temperature difference between high and low latitudes increases, so that a smaller amount of motion is required to form a front, followed by

disturbances and increased motion, until the potential energy represented by the temperature differences is exhausted.

In all the main atmospheric problems there are interrelated variables, and the popular idea of a simple cause of phenomena has little application. There has sometimes been a rather futile discussion as to whether pressure differences cause the wind or *vice versa*. This is merely a special case of the problem of force and acceleration. The development of pressure differences at sea-level requires the accumulation of air over some areas at the expense of others, but the air motions producing these differences themselves require previous pressure gradients, and so on *ad infinitum*. In so far as the idea of cause can be applied at all, the time sequence must be the basis of it. The temperature differences due to astronomical and geographical causes are the primary factors, and air movements and the formation of fronts are secondary to these. The geographical distribution of land and sea, ice and snow, and the effect of ocean currents on temperature are obviously fundamental, but the main emphasis must be placed on the large features rather than the local ones. Geographical discontinuities such as coast-lines or ice boundaries cause large contrasts of surface temperature, but these contrasts only extend upward slowly, and the air is usually moving too much to allow time for the development of a dynamically important surface of discontinuity. Most of the Norwegian school of meteorologists supports the views of Bergeron, Bjerknes, and Petterssen, who place the mean position of the polar front in winter on the dotted line shown in Fig. 9, *i.e.* well to south of the coast and also south of the region of sharp gradient of sea temperature, shown by the dot shading on the diagram. It is essentially the dividing line between the northerly current over eastern North America and the south-westerly current in the Bermuda area. Over most of the Atlantic the two currents run parallel to each other, but there is good evidence that the temperature difference remains large in the upper air. The line represents the region of maximum frequency of non-occluded fronts, but there are great variations between individual cases, and sometimes there is no front anywhere. It is rarely that tropical air extends as far north as Iceland. Fronts in that area are between maritime polar and arctic air, often known as "arctic fronts." The western end of the Atlantic polar front is more pronounced than the eastern end and more depressions form there. Many of these move north-east to Iceland and help to maintain the pressure minimum in that area, which in turn maintains the polar front. In summer the Iceland "low" is smaller and weaker, the American continent is warm, and the polar front is relatively weak and lies farther north than in winter.

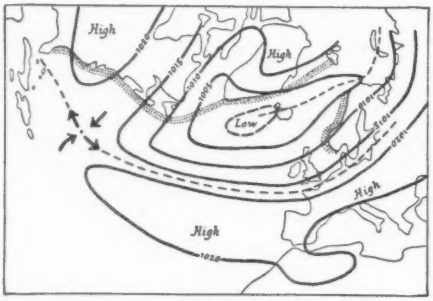


Fig. 9. Mean position of polar front in winter in relation to mean isobars

The primary factor in the formation of fronts (called frontogenesis) consists of the air movements which bring cold and warm masses into juxtaposition and form a diffuse front. In order that the front may become really sharp (*e.g.* 10° F. temperature difference in 10 miles) the intermediate air must be displaced upwards. The necessary ascent is often due to a disturbance which may develop at a front before it is really sharp. When a depression is moving fast or growing deeper there is convergence of the horizontal air motion into the region of falling pressure, involving ascent of air, and this tends to sharpen existing fronts and may form a new one if there is already a gradient of temperature. To some extent both depressions and fronts are self-perpetuating mechanisms, so long as there is a supply of warmth and moisture, as there is over a warm sea surface, and so long as the upper air conditions are suitable for the ascent of air. Of the numerous depressions which form off the American coast or leave the American continent in winter, many are occluded in mid-Atlantic but still remain active, with the occlusions still giving rain, while they move great distances over periods of days and often involve several different air masses during their history. It is for this reason that occlusions are so numerous in our area.

When depressions reach the European continent in winter they usually die out owing to lack of warm air. Even over the ocean a depression may die out, but in most cases only after it has attained a great depth. A very deep depression tends to become stationary or to move only slowly, in which case fronts are twisted up and destroyed and the temperature distribution becomes uniform, so that the supply of energy is exhausted.

Depressions in polar air: instability

Mention has already been made of the importance of a warm sea surface, and some facts may now be mentioned which further emphasize this feature. The warm sectors of an appreciable number of depressions consist of polar air warmed over the Atlantic. This presents no special difficulty except to over-simplified polar-front theory, but a greater difficulty is that a few depressions form in polar air without warm sectors, but with fronts resembling occlusions, with the rain chiefly ahead of them. These may originate in secondary cold fronts in the polar air, or the front may develop entirely after the depression has formed. In either case the most important feature, namely the belt of precipitation ahead of the front, is due to a line of convergence in the depression. There is much indirect evidence that such depressions only form when there is instability in the vertical, and this condition requires some further explanation. It is only possible to give a rough outline here, and for further information reference must be made to a text-book of meteorology. Rising air is cooled by expansion under reduced pressure at the adiabatic rate for dry air till cloud forms, and then at the saturated adiabatic rate. Its temperature-height curve can be represented by the line ABC (Fig. 10), and if at C the rising air is warmer than its environment (represented by D on the diagram) it has buoyancy and continues to rise. When air rises the adjacent air normally descends say from D′ to D, and is warmed at the dry adiabatic rate. In the conditions observed in the layers of the atmosphere which are important for this process (more especially from 5000 to 15,000 feet) the amount of

descent which is compatible with the descending air remaining colder than the ascending air is small, so that there is normally slow descent over a large area and rapid ascent over a small area. Typical showers or thunderstorms have wide intervals between them, and the size of the showers and clear spaces adjust themselves according to the atmospheric situation. There is something of the nature of an arrangement of cells, resembling the cell patterns shown in the well-known experiments of Professor Brunt and Sir Gilbert Walker, when a layer of fluid is made unstable by heating from below. The patterns produced resemble those of stratified clouds, which are often in an unstable condition. The cells often elongate along the direction of wind shear, *i.e.* parallel to the vector change of wind with height, and showers and thunderstorms show similar effects. The coexistence of descending dry air and ascending saturated air complicates the problem, and as soon as precipitation starts there is another complication. The precipitation cools the air below the shower-cloud, and this descends and rushes out in a squall, with a local rise of pressure and all the characteristics of a cold front, though actually it is only superficial and of limited length. Polar currents passing over a warm sea contain a large number of such fronts, and since there is often a gradient of temperature due to progressive heating at the sea surface, the severe squalls which give sudden falls of temperature resemble steps in the general slope, and are of the nature of minor fronts; and though they are relatively short-lived, they may travel several hundreds of miles.

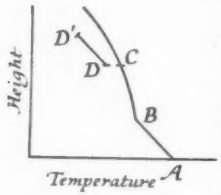


Fig. 10. Instability of rising saturated air

Small belts or areas of instability precipitation, with a slight local rise of pressure below them, do not of themselves tend to form depressions, but the matter is very different when air ascends over a larger area. If there is convergence in the horizontal motion over a substantial area, there need be no descending air between the showers or thunderstorms, and these are liable to spread and amalgamate into belts or areas of continuous rain, while simultaneously a depression starts to form, though this may remain a small affair. Over land in summer small feeble depressions with heavy precipitation often form in thundery weather, and occasionally they develop into important systems. They are often associated with a front, but this does not explain why there should be such an increase of the horizontal extent of the regions of ascending and descending air. Falling pressure and convergence of horizontal motion, and hence general ascent of air, occur simultaneously, developing from small origins in a vicious circle which intensifies the disturbance as far as the supply of energy allows.

When there is development of a depression without a front there is usually, perhaps always, a variation of wind with height, and for reasons well known to meteorologists this involves a horizontal gradient of upper air temperature. Convergence can readily form a front in such a region, and this explains why the appearance of a front occasionally follows rather than precedes the development of a depression. When upper air research has been more fully developed, it may well be found that a zone of pronounced wind shearing

constitutes the most important general factor, and includes a surface of discontinuity as a specially well marked case. The vertical distribution of temperature and humidity are also involved, and in all probability the less the vertical stability the smaller is the amount of shear required to start the disturbance. The formation of a cyclonic centre at some point on the zone of shear, with the associated convergence and development of wind circulation, is a problem not yet solved. Once there is sufficient convergence, the earth's rotation supplies the angular momentum required for circulation.[1]

The supply of energy

Considerations of energy also bring in both the horizontal temperature gradient and the vertical structure of the atmosphere. We need only consider the conditions actually observed in the atmosphere, and it is found in all cases of cyclonic development that the latent heat of condensation plays a decisive part. The mere occurrence of rainfall does not necessarily mean that kinetic energy is developed. It is essential that the rising air should be warmer than the descending air, which may be part of the same air mass, as in the case of a typical thunderstorm above the cloud base, or of a different air mass, as at a sloping surface of discontinuity, where the horizontal scale is large and the descending air may be hundreds of miles from the ascending air. This requirement implies that the depth of cold air is very important, and its degree of coldness high up, before it starts to descend. In the case of a shower or thunderstorm the kinetic energy appears chiefly as vertical motion and is dissipated by turbulence. The development of horizontal motion requires the setting up of a horizontal pressure gradient, and circulation round a centre needs convergence of air with ascent on an adequate scale. Before the horizontal circulation can increase, the dissipation of energy by friction with the ground must be overcome. It is probably because the friction over the sea is much less than that over land that intense depressions are more numerous over the sea than over the land even in summer.

Final conclusions on depressions

It is now clear that all important depressions of temperate latitudes have one feature in common, namely the ascent of a large mass of saturated air with colder air partly, but not entirely, surrounding it. (Tropical cyclones are probably surrounded by relatively cold air.) The warm damp air may have come from subtropical regions, but on the other hand it may have gained moisture and relative warmth from the sea surface in quite high latitudes. The sea south of Spitsbergen is an effective warm source owing to the proximity of very cold areas. Deep depressions fed from that source may cross the Pole or invade Siberia, but they begin to lose intensity not more than twenty-four hours after becoming detached from the source of warmth.

The conclusion we have reached shows that the old convectional theory of Ferrel had a great deal of truth in it, though naturally it requires modification in the light of new facts. The fully developed depression of temperate latitudes does not consist of a warm column of air, since it is now known that the

[1] D. Brunt, "The dynamics of revolving fluid on a rotating earth," *Proc. roy. Soc. A.* 99 (1921) 379.

ascending warm air goes forward from the centre of the depression as it spreads out aloft, and that cold air from the rear occupies the centre, usually right through the troposphere. The direct cause of the low pressure is divergence of motion in the upper troposphere due to dynamical factors, of the nature of which some knowledge has been obtained in recent years, though this is still inadequate. The ideas of Ferrel, W. H. Dines, Bjerknes, and many others have all contributed to our present knowledge of the subject.

Before leaving the subject of depressions it is necessary to point out that the same essential features have been observed all over the temperate zone in the northern hemisphere, and also in New Zealand. The typical development from a wave-like disturbance on a front to a deep occluded depression is independent of local factors, though the relative frequency of young and old depressions varies with geographical conditions. This variation must obviously be larger in the northern than in the southern hemisphere.

Anticyclones

Regions of high pressure are the necessary counterpart of regions of low pressure, but the well-developed, often long-lived, anticyclones found in nature are not altogether the counterpart of depressions, but seem to have a semi-independent existence of their own. It is rarely possible to correlate the development of an anticyclone with that of any one depression. Just as depressions require the ascent of warm damp air, so anticyclones usually require the descent of cold air, which is warmed by compression in its descent and thus becomes very dry, except perhaps close to the earth's surface. An anticyclone cannot develop actually on the polar front, since the wind discontinuity at the front is necessarily of cyclonic type (see Fig. 1). When the front has a southward bulge (opposite to that of the warm sector of a depression) an anticyclone readily develops in the cold air to northward of the front. Other cold anticyclones move south-eastward from the arctic regions. Cold anticyclones tend to move equatorwards, on the average about E.S.E. (whereas depressions move E.N.E. on the average). They build up or maintain the more persistent "warm" anticyclones, normally located in the Horse Latitudes. A cold anticyclone often develops into a warm one. The cold air is warmed by the descent and spreads out in the lower half of the troposphere, and tropical air with a warm troposphere and a cold stratosphere flows over the top of it, rendering the whole system stable. Warm anticyclones are normally focused round the Azores, but may be much farther north, occasionally as far north as Iceland. Over the British Isles they may give prolonged periods of drought, as in the spring of 1938. Persistent anticyclones are reinforced from time to time by fresh bursts of descending cold air, but importance must also be attached to the upper part of the system with its cold stratosphere. Occasionally an anticyclone intensifies entirely in tropical air, so that the earlier statement about descending cold air had to be qualified by "usually."

There is a limiting value to the clockwise rotation of an anticyclone which is much less that of the anti-clockwise rotation of an intense depression. This is because it is impossible to set up on any large scale on the earth's surface clockwise rotation in space. Divergence of motion sets up anticyclonic

rotation relative to the earth, and this is weak cyclonic rotation (*i.e.* in the same direction as the earth's rotation, only weaker) relative to axes fixed in space.

The general circulation

The so-called "general circulation" of the atmosphere is a representation of average conditions, and care is required in its interpretation. It is a mistake to regard it as a stable condition upon which cyclones and anticyclones are superposed as incidental features. Dr. H. Jeffreys has shown on theoretical grounds that a circulation would be impossible without interchange of air between high and low latitudes on the scale which cyclones and anticyclones actually provide. It is a matter of observation that such a dominant feature in the general pressure distribution as the Iceland low-pressure centre is in fact a region where depressions moving north-eastward attain their maximum depth. They often originate off the American coast and continue deepening long after their first occlusion, owing to the warm seas south of Iceland and the adjacent cold air in the Greenland area. Depressions also often originate near Iceland. The associated fronts may be of instability typeand are either short-lived or quickly come to resemble occlusions, and these are normally called occlusions.

The atmosphere has been compared to a gigantic engine of which the boiler is in the tropics and the condenser in the polar regions, but though this conception has some value as a bird's-eye view, the actual problem is far more complicated. Any part of the earth's surface where heat or moisture is being added to the overlying air is in effect part of the boiler, and in winter the whole of the Atlantic and the open water off northern Europe acts in this way much more often than not. The same is true over land in summer, but land is not usually so effective a boiler as the sea, since there is often a shortage of moisture, and since cooling takes place at night. The regions covered with snow or ice are obviously the most effective as condensers. Since these areas are much smaller than the boiler areas, even in winter, it appears at first sight as if a given area in the Arctic must be much more important than an equal area elsewhere. But another fact to be taken into account is that all over the globe the upper layers of the troposphere radiate more heat than they receive and hence form part of the condenser. The climatic importance of the arctic regions is obvious, but it is not yet possible to compute exactly for what proportion of the atmospheric disturbances they constitute the condenser. It is at least certain that no very special importance can be attached to the $1\frac{1}{2}$ per cent. of the surface of the hemisphere situated to north of 80° N. Low upper air temperature is far more important than low surface temperature, but the upper air temperature is affected by the nature of the surface below.

The high level of the Greenland plateau gives it a special importance, but this has sometimes been exaggerated. The energy of the katabatic winds is dissipated locally by friction. So long as the katabatic winds are really cold and are not foehn winds (as sometimes occur, especially in west Greenland) they act as a pool of cold air which forms a part, but only a part, of the general cold supply. A system of outflowing katabatic winds does not constitute an anticyclone in the usual sense of the term. Real anticyclones over Greenland

often cause cold snaps in the British Isles, especially in spring, but observations from north-west Greenland now show that they are frequently already existing polar anticyclones moving south-eastward.

All mountain ranges act as obstacles to air movements and tend to deflect the air currents. Greenland acts in this manner, but there are only a few cases where this deflection appears to have much importance. Depressions sometimes cross Greenland or other high areas, travelling in the upper air and afterwards re-forming at sea-level.

The exchange of heat between low and high latitudes is carried out mainly by the irregular currents of cyclones and anticyclones. If one considers the whole atmosphere, the net flow of air across a parallel of latitude is zero when averaged over a long time. If one takes one layer only it is not necessarily zero. Close to the ground friction causes a component of flow towards the poles in the zone of westerly winds, but in the lower troposphere as a whole there is probably a slight southward movement, and a northward movement in the upper troposphere. This is due to the large amount of warm air which is displaced upward by the occlusion process. The horizontal and vertical movements work in together. The air which rises in a depression does not usually descend till after it has travelled a great distance and been cooled by outward radiation.

Exchange of air between one latitude and another is greatest where cyclonic activity is most intense, for example round Iceland, but it is nowhere zero, and no part of the atmospheric circulation can be treated as if it were a self-contained system.

We have seen that the source of heat and moisture which is the essential driving force of atmospheric circulation of all kinds lies at the bottom of the atmosphere, especially over warm sea surfaces; loss of heat by radiation to space, which in the long run balances the amount of solar heat absorbed, takes place partly from the earth's surface in high latitudes and partly from the upper air in all latitudes (but especially in high latitudes), and there is reason to believe that the radiation from the upper troposphere is specially important for the atmospheric circulation. The transfer of heat is upwards as well as from south to north. The mechanism of atmospheric movements is essentially three-dimensional, and involves all parts of the troposphere, and to some extent the lower stratosphere, and this makes the whole problem complex. There are various schools of opinion, but it is probable that the majority of meteorologists regard the lowest half of the troposphere, up to some 5 kilometres (3 miles) of height, as exercising more controlling influence than the rest of the atmosphere.

DISCUSSION

Before the paper the PRESIDENT (Field-Marshal Sir PHILIP CHETWODE) said: In introducing Mr. Douglas to you this afternoon I must confess that he is going to speak to us on a subject of which I know very little. Nevertheless it is a subject of great importance. Mr. Douglas has more experience than any of us in the application of the polar-front theory, which is, I believe, of Scandinavian origin, and which is often mentioned and discussed at length, but seldom fully explained. I ask Mr. Douglas now to give his paper.

Mr. Douglas then read the paper printed above, and a discussion followed.

Dr. H. R. MILL: As a meteorologist I have been interested in Mr. Douglas's able demonstration of the complexity of the polar front, for I was brought up at the feet of Alexander Buchan, who was, I think, the first modern meteorologist to recognize the importance of the movements of the upper air in determining weather and climate at the earth's surface. He established the Ben Nevis Observatory and made accurate observations at 4000 feet long before the days of sounding balloons, kites, or aeroplanes, but he had difficulty in getting any one to pay attention to what he believed would prove the most important aid to weather-forecasting. So I rejoice to see how completely the foresight of my old master has been vindicated. I well remember how I was attracted in my meteorological studies by the title of Ferrel's work 'A popular treatise on the winds,' and how I struggled through the book, compared with the obscurity of which the discourse we have listened to this afternoon is as pellucid as an autumn sunset. I had the opportunity of talking with Professor Bjerknes, who first developed the theory of the polar front, and from his description of his early efforts to gain attention for his theory I can imagine how greatly he must appreciate the way it has now been taken up and used.

As a geographer I think we should have appreciated Mr. Douglas's discourse more fully if he had taken compassion on our general ignorance of the new terms in meteorology and explained to us something about the nature of anticyclones, cyclones, katabatic winds, the stratosphere millibars, and the like; terms essential in treating of the subject from the meteorological point of view, but not yet familiar to all. Of course we as geographers are more accustomed to follow the advances of climatology than of pure meteorology. I think that in studying the movements of masses of cold and warm air we may get a certain steadying of our ideas by looking first at the movements in three dimensions of less mobile media than the elusive air. Many of us remember the pleasure with which we heard a description of the work of the R.R.S. *Discovery II* in connection with the movements of the cold Antarctic water meeting with the warmer water of the subtropical oceans, and the very happy word "convergence" which Dr. Deacon coined as descriptive of that South Polar Front in the sea. One could easily see how the two currents came together, mixed or stratified, and took part in the general circulation of the ocean. Just in such a way, but with infinitely greater complexity, do the currents of warm and of cold air of the polar front come together, mix or slip under or over each other, whirl around in turbulent motion, and set up those depressions and anticyclones with which we are familiar.

As a member of the general public I have only one remark to make, and it is to congratulate heartily the Meteorological Office on the way in which by adopting the theory of the polar front they have improved the trustworthiness of the weather forecasts and made them so nearly accurate that instead of people expressing surprise, as they used to thirty or forty years ago, when a weather forecast came true, they now have a feeling of being very badly treated if the weather is not precisely as promised.

Dr. T. G. LONGSTAFF: I want to ask the lecturer a question concerning history, or rather pre-history, in which I am much interested. I understand that the polar front at the present time is south of Iceland. I gathered from Professor Lauge Koch that modern Danish geologists are inclined to put the date of the last extension of the Norwegian ice cap into Denmark at only six thousand years ago. When the Norwegian ice cap extended into Denmark the polar front must have been, I suppose, very far south of where it is to-day. It seems to me that if the polar front was previously much farther south than

now it would explain the apparent anomaly that although more excavation has been done in the British Isles and in central Europe than anywhere else in the world, yet the earliest remains of cities of *civilized* prehistoric times of 3000 B.C. are found on the Indus near the edge of the Sind desert, in Mesopotamia and Asia Minor, in pre-dynastic Egypt, in countries which are now semi-desert. Of prehistoric towns of the fourth millennium B.C., that is of six thousand years ago, there is no trace north of the Mediterranean. I ask the lecturer whether a possible explanation of that is that the polar front having formerly been so much farther south than now, the weather zones would also have been moved south so that the storm belt was over the Mediterranean, and therefore climatic conditions existed over these now arid lands which were much more apt to the development of humanity. This would account for the origins of civilization having commenced so far south of what we find is the centre of civilization to-day.

Mr. C. K. M. DOUGLAS: It is generally agreed among meteorologists that during the Ice Age the other climatic zones moved southward. Dr. Brooks has discussed the subject in his climatological works.

Mr. L. C. W. BONACINA: I think that one might conceive of the polar front either as an actuality or as a generalization. In regard to the southern hemisphere, where there is a constant stream of air flowing out from the high plateaux, meeting equatorial air, and being concerned with the formation of cyclonic systems sweeping round the southern ocean, it can, I think, be said that the polar front is an actuality. But in the northern hemisphere, where there is such a complex distribution of land and water, the distortions and subversions of any theoretical polar front are such that the conception becomes a generalization, though nevertheless a very valuable one in helping the meteorologist to keep his bearings, especially in weather-forecasting.

Weather-forecasting, though still far from being reliable, has, as Dr. Mill pointed out, greatly improved in recent years. There seems to me however to be a danger attendant upon the increasing accuracy of official forecasting: that the public and especially unofficial meteorologists will cease to develop their open-air weather sense. A careful observer of the sky will often get a hint when the official forecast is about to go wrong, and in any case circumstances will always arise when individuals with a sound local weather sense may render invaluable services.

Mr. A. R. HINKS: I have been greatly interested in this question of the polar front since I spent some years ago an agreeable afternoon with Professor J. Bjerknes in the Institute at Bergen. I would like to make one suggestion. It has seemed to me, having these meteorological diagrams before us, that there is some possibility of more intelligible representation if one can apply to them an excellent principle of the Ordnance Survey before the War, that the numbers should stand upon the contours on the upper side. That principle was one of the casualties of the Great War. It has never been revived, but I think that something of the kind would be useful in interpreting the weather diagrams.

A FELLOW: Might I suggest that different types of lines be used? It would be a great convenience if one could see by the types of lines more or less automatically whether there is a depression or the opposite in the weather.

The PRESIDENT: It only remains for me to thank the lecturer cordially for what to me has been rather a scientific lecture. It has evidently interested many members of the audience, and I ask you to convey, in the usual manner, our sincere thanks to Mr. Douglas for coming here and reading to us such an interesting paper.

SNOW-PATCH EROSION IN ICELAND

W. V. LEWIS

SNOW-PATCH erosion seems to be very important under peri-glacial conditions, and yet, as Bowman [1] has noted, there has been little mention of it. The subject was dealt with briefly after the Cambridge Iceland Expedition, 1932,[2] and in order to amplify the field-work carried out on that occasion a second visit was arranged for the summer of 1937. The site chosen was Snaefell, a Late Glacial volcano [3] with subsidiary cones, a few miles distant from the northern edge of Vatnajökull. We hoped to see much of the summer melting, and although Snaefell was not reached until mid-July, we were fortunate in that the season was a late one. Countless snow-patches lay within easy reach of the base camp; many were permanent, but most melted away during our stay. Snaefell rose 3500 feet above us, so that by climbing we could examine snow-patches in which the cycle of seasonal melting had not proceeded so far as with the lower ones. The snow-patches were rather more frequent on slopes facing north and west, but protection from the sun's rays seemed to be only one of the factors tending to preserve them, the chief factor being their bulk.

The processes involved in snow-patch erosion fall into the larger category of nivation phenomena, and the hollow in which the snow lies will here be referred to as the "nivation hollow."

The snow-patches in the vicinity of Snaefell can be divided into three classes. First transverse snow-patches whose major axes lie transverse to the lines of drainage, secondly longitudinal snow-patches elongated downhill, and thirdly circular snow-patches which, though transitional between the other two in ground plan, are frequently of far greater thickness. This last type appears to represent an initial form of cirque glacier.

Transverse snow-patches. The transverse snow-patches varied in length from 100 yards to a mile or more, and in width from 20 to several hundred yards. Near our camp was one which, though small, was typical. It had just subdivided when we arrived on July 16, and the major portion was then about 120 by 40 yards. It occupied the angle at the foot of the eastern slopes of a subsidiary ridge of Snaefell. In Plate 1, taken on July 31, it is much reduced in size, and it finally disappeared on August 19. The back slope of the nivation hollow was steeper than that of the mountain above. A section drawn from a line of levels run across the left side of the snow-patch on July 18 is shown on p. 154. The nature of the surface along this line was representative. The low ground was covered by coarse grasses, frequently in hummocks, and interspersed with dwarf willow where the ground was slightly drier. Near the snow-patch the grass cover ended abruptly and the surface dropped a foot or more in level. Superficial digging here showed that the subsoil was frozen,

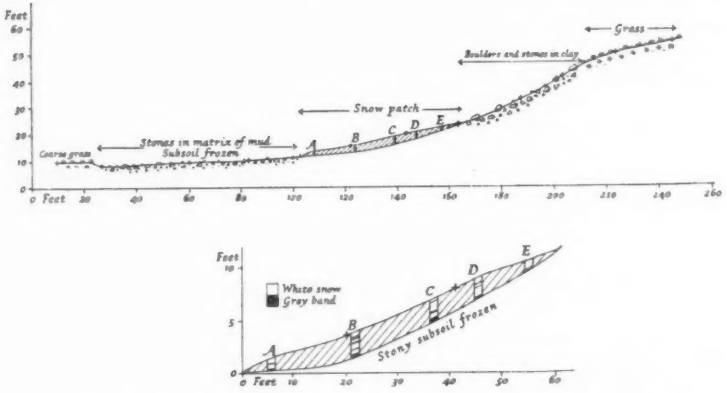
1 Bowman, Isaiah, 'The Andes of southern Peru,' New York, 1916, p. 311.

2 Lewis, W. V., "Nivation, river grading, and shoreline development in south-east Iceland," *Geogr. J.* 88 (1936) 431–47.

3 Ahlmann, H. W., "Vatnajökull; scientific results of the Swedish-Icelandic investigations, 1936–37," *Geogr. Ann. Stockh.*, No. 39, 1937, h. 3–4, p. 168.

and this, together with the gentle gradient, largely accounted for the sodden nature of the top-soil. The latter consisted of stones and small boulders in a matrix of fine silt and clay. Water followed ill-defined channels through this material and was deflected by the vegetation front until it formed a stream large enough to maintain a course through this cover. Above the snow-patch the slope increased to a maximum gradient of 30° and the ground was again bare, but here it was much drier and consisted of boulders and stones in clay. The sudden decrease in grade above this zone corresponded to the change from bare soil to vegetation. The whole of the unvegetated zone was probably covered by the snow-patch in the spring.

Melting was greatest when rain was falling, but even under normal melting conditions tiny runnels flowed from underneath the snow-patch and contributed to the sodden state of the ground below. These small runnels constantly moved material up to the grade of a medium sand, even when the slope



was gentle. During heavy rain, no runnels were visible on the ground free from snow-patch drainage.

On July 18 a series of pits were dug along the levelled line. The results are shown in the diagram above (lower portion). The vertical scale is double the horizontal to enable the thinner bands of grey snow to be represented. Heavy rain had fallen overnight which turned into intermittent mist and rain in the course of the day. Section E was dry to the bottom, the subsoil being frozen hard; it remained so for a quarter of an hour and then became damp. The ground below pit D was also dry and frozen hard when uncovered, but moisture began to form immediately. The ground below C was similarly frozen, but there was a lot of moisture passing over the surface, whereas below B the soil was covered by 3 inches of waterlogged grey snow. The bottom of the lowest pit A also had a layer of waterlogged snow, and like pit B had water passing over the surface of the ground when it was exposed. The pits were dug in the order A, B, C, so that when examined they were unaffected by any previous digging.

The steadily increasing dampness towards the foot of the snow-patch

showed that the snow itself was the source of the moisture emerging from the foot of the patch. The waterlogged lower layer of snow resembled slush and the water both poured into the pits from this layer and seeped back into it on the lower side. The sections, when examined again two days later after more heavy rain had fallen, showed the pits greatly enlarged and the patch much reduced in size. The top pit E had now merged with the ground above and a tongue of clay and stones had sludged down into it. The next section D had a small runnel along the floor which was transporting clay and fine black sand, both of which were being carried under the snow on the lower side. Pit C contained a much smaller runnel, but this also removed both grades of material and several little pools had small debris-fans where runnels entered. Pit D contained a strong runnel entering a pool in which the coarse material formed a fan and the finer was deposited evenly over the floor. The bottom section, like the top one, had merged with the ground outside the snow-patch, and it contained a strong runnel. All grades of sand together with the clay were being carried by this little stream, and isolated pebbles of vesicular basalt and of tuff over a tenth of an inch in diameter were being moved intermittently. The presence of the pits did not greatly exaggerate the movement, for runnels as large as the one emerging from pit A, and similarly charged with material, occurred every 4 or 5 feet along the lower margin of the snow-patch. Sixty to eighty such runnels must have been moving a considerable amount of material from beneath the patch.

The mass of snow showed no signs of downhill movement, so that all the transport was done by melt-water. The runnels were clearly unable to erode or scour the rock surface; they merely transported material that had already been loosened and comminuted by other agencies. The very moist conditions of the lower pits could not have been permanent, otherwise at least the surface of the frozen subsoil would have melted, as it had beyond the snow-patch. Thus at night, during cold dry spells, the whole of the terrain below the snow probably froze hard. Such alternate melting and freezing would readily shatter the bedrock, the loosened fragments would themselves be broken up, and each shattering would yield a supply of fine material. The abundance of this fine material at the toes of snow-patches bore witness to the power of frost action to comminute material, a point stressed by Matthes.[1] Neither frost action nor the runnels of melt-water could alone excavate the nivation hollow. The rate of comminution of the underlying bedrock and the slow supply of material from above by downhill creep were evidently well able to keep pace with the removal by the runnels under the snow-patch, for the solid rock beneath the patch had an ample cover of predominantly fine material.

In this way nivation hollows probably recede a little farther into the hillside each season, increasing the height of the steep back slopes. Each winter a correspondingly greater thickness of snow accumulates as drifts banked up against the little cliffs, and so the excavation continues. The accumulation of snow in the form of drifts is important, for the processes of nivation can only last as long as the supply of moisture remains adequate, and this in turn depends on the volume of accumulated snow. It is clearly not a case of

[1] Matthes, F. E., "The glacial sculpture of the Bighorn Mountains, Wyoming," *Rep. U.S. geol. Surv.*, 1899–1900, Pt. II, p. 180.

unequally distributed snowfall, but merely of unequal capacity to collect drifting snow. Eventually the accumulation becomes sufficient for the snow-patch to last throughout the year. A second factor which tends to concentrate such action in patches is that the vegetation cover must be absent for active nivation. Small snow-patches aid the vegetation because they afford both a supply of moisture and insulation from excessive cold in the early spring, and the hollow gives some shelter from the wind.[1] But when the snow-patch is large anough to last into the summer it kills the vegetation and so accelerates nivation. At elevations greater than about 3000 feet the vegetation cover is absent, and so this factor becomes inoperative.

The snow-patch described above was one of the smaller ones on the eastern flanks of Snaefell. The lower slopes of the mountain within a few miles of the base camp faced east and rose at a gradient of about 15°. At intervals elongated nivation hollows containing snow-patches broke this uniform slope. Some were over half a mile in length and formed minor terraces on the hillside. The initial location of the snow-patches was probably determined by softer beds in the more or less horizontally bedded tuff which, with minor intercalations of vesicular basalt, formed the underlying rock. A typical patch occupying a nivation hollow of intermediate size, though still very immature in form, is shown in Plate 2, taken on August 17, when it was much reduced in size. Only three weeks earlier this patch was 600 yards long and reached to the top of the steep unvegetated slope. This terracing of a hillside, though seen here in what is clearly an initial stage, might assume considerable physiographical importance if it were carried many stages further.

The west-facing side of this ridge, which was of much less vertical extent, had only one major snow-patch, and this was continuous for nearly a mile. It was situated immediately below the crest of the ridge. Several other subsidiary peaks and ridges of Snaefell had similar snow-patches on their western sides. The reason for this location seems to be that the snow falling during an east wind is blown clear of the summit but comes to rest on the more sheltered slopes immediately below the crest of the ridge. This location for snow-drifts is well known to Alpine glaciologists.[2]

Longitudinal snow-patches. Most of the snow-patches in our area fell into this category. The upper slopes of Snaefell are furrowed on all sides by narrow gullies, each containing a snow-patch early in the season. Plate 3 shows the southern flanks of the mountain on August 14, when only the larger patches remained. As each gully contained a little stream it was not so easy to estimate the amount of snow-patch erosion. Later in the season the patches subdivided and the streams issuing from ice-caves exposed the ground beneath. These caves showed much the same features as those in the pits described above. The stream courses were boulder-strewn and the water carried some fine material. The contact zone between the snow or ice and solid ground on either side of the cave was generally damp, and muddy material frequently sludged downwards into the stream and was washed down by numerous runnels. The dampness increased rapidly towards the lower end

[1] Falk, P., "Plant ecology in the vicinity of Snaefell, E. Iceland." In course of publication in the *Journal of Ecology*.

[2] Seligman, G., 'Snow structure and ski fields,' London, 1936, p. 210.

1. Subdivided transverse snow-patch, much reduced by melting, 31 July 1937

2. Transverse snow-patch in immature nivation hollow, 17 August 1937

3. Southern slopes of Snaefell with longitudinal snow-patches, 14 August 1937

4. Small circular snow-patch, 11 August 1937

5. Circular snow-patch and ice-cave, 11 August 1937

6. Steep slope at the head of a circular snow-patch, 20 August 1937

of each patch and more water dripped from the roof in the smaller than in the larger patches. Although dampness increased as the patches dwindled, the total amount of erosion accomplished each season must be greater for the larger patches, because the disintegrating processes of freezing and thawing and the washing out of the material continue for a longer period.

Several gorges, cut deeply into a mass of tuff on the eastern face of Snaefell, indicated that stream erosion can, under certain conditions, proceed more quickly than nivation. Some of these gorges, only a yard across, were more than 40 feet deep and half a mile in length. They were usually bridged by snow to within 5 or 10 feet of the top, but where the rock face was exposed above this level swirl marks and pot-holes, though much weathered, were still visible, showing that nivation had been negligible during the period of gorge cutting. These instances were however definitely exceptional.

An estimate of the efficacy of nivation in longitudinal snow-patches could best be made in examples which showed definite departures from normal stream gullies. These were usually of the type with terraced cross-sections opening wide at the top so that they collected much snow. Plate 3 shows, in the foreground, a well-developed minor cliff formed in the side of a little valley. The valley and the greater part of the snow-patch are hidden. The snow occupied a bench in the valley side and the cliff above the snow was steeper than the slopes bounding the stream itself. There can be little doubt that here the snow-patch was widening the valley by sapping the base of the cliff. The soft tuff was probably much subject to frost-shattering and the resulting material was removed by runnels into the stream below.

Before leaving the question of longitudinal snow-patches reference should be made to another way in which they contribute to the downhill movement of material. On the east face of Snaefell a series of steeply inclined snow-patches led up to the summit. At intermediate levels they carried long thin tongues of black debris. When followed upstream these tongues usually started at the sides or at junctions of patches, and were due to a form of solifluction phenomena which we witnessed on several occasions. During the height of summer melting, when the subsoil at the margins of snow-patches was still frozen, material sludged down on to the snow and continued over the surface until the moisture, which initiated the movement and then acted as a lubricant, melted its way down into the snow. Fuller reference has been made to this action elsewhere.[1]

Circular snow-patches. The circular snow-patch was not as frequent as the other two types, but it was often of much greater thickness. The small patch depicted in the left of Plate 4 was all that was left on August 11 of a patch which, in the middle of July, had filled the entire hollow and also covered most of the bare ground visible as a scar extending across to the right-hand side of the photograph. The rounded form of the hollow containing the snow was quite unrelated to stream action, which had formed only the two small gullies visible in the photograph. Matthes [2] attributes the rounding of nivation hollows to marginal melting. In Iceland any attenuated limb became

[1] Lewis, W. V., "Dirt-cones on the north margins of Vatnajökull, Iceland." In course of publication in the *Journal of Geomorphology*.

[2] Matthes, F. E., *op. cit.*, p. 181.

pinched off or melted away quicker than the snow of a margin with lesser curvature, for the surrounding rocks and bare drift, owing to their greater capacity for absorbing radiation, reach a far higher temperature than the snow surface. Dust also blew on to the edge of the patch, and this further accelerated melting by acting as a heat absorbent. Thus it might well be that, in the absence of any other factor tending to determine the shape of the patch, the circular form, having the least periphery per unit area, will result. In the patch shown in Plate 4 the bare rock is visible at two points on the steep back slope and in neither instance is the exposure due to stream action. At the rock exposures the speed of removal was evidently in excess of the rate of comminution by freeze-thaw processes.

The largest permanent snow-patch near the camp lay in a ravine at an elevation of 2500 feet. It was well suited for study because a cave extended beneath the snow-patch for about 50 yards. The patch is visible in the top left-hand corner of Plate 1, and Plate 5 shows it much nearer on August 11. At the beginning of our visit the snow encompassed the cliffs on the right and extended beyond the limits of the photograph on the left. It thus considerably overlapped the ravine. The main patch was about 350 yards by 200 yards, and judging from the inclination of the floor of the cave and the surface of the patch the maximum thickness must have been quite 50 feet.

Where the snow spread on to the hillside and drained away from the ravine, conditions approximated to those at the transverse snow-patch first described. The surface was saturated and a considerable amount of fine material was being carried away. Far the greater part of the melt-water however flowed into the main stream. This stream entered the snow-patch from above, and derived its water from a number of tributary longitudinal patches. Just inside the cave the stream had cut a little gorge below the general level of the base of the snow-patch; beyond, the cave widened to 30 feet. The gorge was cut in the harder bands of tuff and lava which formed the cliffs on either side of the entrance. Still farther in we were stopped by a rock barrier down which the stream cascaded. The temperatures of the air and water on July 18 were as follows:

Outside air temperature	56° F.
Air temperature in the entrance	48
Air temperature 50 yards from the entrance	48
Temperature of water dripping from the roof ..	34
Stream temperature in the cave	36

Water streamed from the hundreds of little cusps in the roof. The latter consisted of hard ice produced by the freezing of melt-water, for the thickness of the snow was not nearly sufficient for the transformation into ice by pressure. Near the gorge the ice rested on bare rock, but usually there was an intermediate weathered layer of coarse angular stones, silt, and clay, the stones being frozen into the finer matrix to a depth of 6 inches below the surface of contact with the ice. Below this level, where the material was exposed to the air, it was unfrozen.

By August 11 the much-diminished snow-patch seemed damper underneath and the sides of the cave were covered in places with a thin layer of

liquid mud. Yet the total amount of water in the stream was less than previously. The basal layers of ice were still frozen to the loose material beneath in the drier places, though the moisture seemed more widely distributed than on earlier occasions when the only really wet parts were below the little circular melt-holes which pierced the roof. These varied from a quarter to more than an inch in diameter and usually carried a trickle of water. By August 20 melting had revealed the back wall to the extent shown in Plate 6. The abrupt fall of the ground at the beginning of the snow-patch is well shown. The stream itself is sculpturing only a narrow zone of this cliff and the latter is steeper where it is free from stream action. Thus the snow-patch seems to be actively sapping this headwall. Radiation from the headwall had caused the snow to recede and so to augment the supply of melt-water for frost action.

Thus wherever the contact between the snow-patch and the underlying material was examined there were signs of erosion, so that the patch appeared to be incising itself ever more deeply into the hillside. Although the adjacent slopes were steep and the lower layers of ice, no thrust planes or other signs of active downhill movement were seen. The basal layers were frozen hard to the ground except where water or radiation had caused melting along the surface of contact.

Melt-water in the cave increased as the patch became thinner near the entrance. This was due to some of the surface melt-water not reaching the ground below where the patch was thick, probably because it was held up on meeting the ice layer. Here any moisture that refreezes would help to thicken this layer and the remainder found its way to the bottom by percolation and through melt-holes. Consequently most moisture reached the floor near the edges of snow-patches and where the patches were thin. Most material is thus washed out from beneath the edges, particularly those on the lower side. Here also the severity of frost-action is probably greatest as the oscillations of the temperature across the freezing-point reach the underlying material, partly by conduction through the thin snow cover, and largely through the agency of the numerous melt-water passages. This zone of maximum destruction would recede with the receding margins as envisaged by Matthes.[1] The ice-cave allowed temperature changes to reach many parts of the floor which otherwise might suffer far less frequent frost-shattering. The severity of frost-shattering was probably greatest in spring when day and night temperatures regularly crossed the freezing-point, for in July and August the night temperatures rarely fell below freezing-point at the base camp 400 feet below. Higher up Snaefell the night temperatures fell below 0° C. both in July and August.

In a snow-patch of this type with a large stream running through it, full allowance must be made for the work done by the stream itself. It quickly removes the fine material carried into it by runnels of melt-water, and in addition does a considerable amount of erosion, such as gorge cutting, through the normal agencies of stream sculpture.

This snow-patch was present late in the summer of 1936 when one member of the 1937 party saw it, and in July 1935, as shown in a photograph taken by

[1] Matthes, F. E., *op. cit.*

S. Thorarinsson.[1] The limit of melting in 1936 is probably represented by the top dust-band a few feet above the heavy black line over the entrance of the cave shown in Plate 5. The heavy band seems to represent the concentration of dust resulting from several seasons' melting. The sagging of this band over the entrance suggests a certain amount of differential movement in the unsupported snow and ice. Were it not for this movement the size of the cave would increase by melting each summer until the roof would collapse.

On the east face of Snaefell were two steep valleys at about 4300 feet above sea-level. Both had well-marked steps formed by horizontal basalt flows below which were large snow-patches. They had already developed the half-funnel shape so characteristic of large nivation hollows, but were clearly in the transitional stage between nivation hollows and cirques, for the *névé* in one case had begun to move downhill forming a fine series of arcuate crevasses where the surface gradient was about 15°. At the lower limit of this snow-patch there was no sign of movement or of end-moraines; it fed the stream which had cut the deep narrow gorge mentioned above. This example shows that the transition from a large snow-patch to a small cirque glacier might be a very gradual one. The most satisfactory distinguishing feature is that of movement. The presence of ice in the lower layers can obviously not be taken as the criterion. Whether or not the crevasses were due entirely to differential movement within the mass or in part to movement of the mass over the ground beneath could not be determined. Their arcuate form, their parallelism, and their V-section suggested that they were due in the main to differential movement within the mass. When, as in the case of a glacier proper, a composite mass of snow and ice begins to move over the rock floor a new set of sculpturing agents is introduced which lies outside the scope of this paper.[2]

A fine series of funnel-shaped hollows or embryo cirques occurred high up on the southern flanks of Snaefell. A particularly massive series of horizontal basalt flows forms a terrace and scarp, seen on the sky-line in Plate 3, at an elevation of about 5000 feet. The largest nivation hollow is in the centre of the photograph and two minor ones are seen just to the left. The largest snow-patch seemed to be semi-permanent, judging from the exposure of dirty *névé* which rapidly increased in area towards the end of August. There was a marked rounding of the contour of this nivation hollow near the crest. The waterfalls pouring down the face of the cliff from the summit ice-cap have barely notched the cliff, so that it must recede by nivation as quickly as the stream channels do by waterfall recession, a clear indication of the potency of nivation processes at this altitude. The rounding of the contours of semi-permanent and seasonal snow-patches has been dealt with elsewhere.[3] Briefly, in a snow-patch the removal of material down the back slope takes place at an approximately uniform rate. This movement converges on the apex of the snow-patch, from which point it is removed by the stream. Hence the slopes

[1] Ahlmann, H. W., *op. cit.*, p. 166.

[2] See Lewis, W. V., "A melt-water hypothesis of cirque formation," *Geol. Mag.* 75 (1938) 249. Also Lewis, W. V., "The function of melt-water in cirque formation." In course of publication in the *Geographical Review*.

[3] Lewis, W. V., *op. cit.* (1936), p. 434.

converging on this point will tend to be uniform and so a rounded contour will result. This contrasts with a normal stream-head below the spring line, where the slope is least along the bed of the stream and more or less equivalent to the angle of rest on either side, thus giving the contours a V-pattern.

Thus in Iceland nivation hollows different in form result from the three classes of snow-patches. The transverse snow-patches, whose shape is generally due to horizontal outcrops of varying resistance or to the junction of the hill-slopes with the flood plain, give rise to elongated nivation hollows which terrace the hillsides. The longitudinal snow-patches follow drainage channels and sometimes modify the cross-section of the stream gullies. The circular snow-patches which form in slight concavities, or when horizontal outcrops cross stream channels, are perhaps of greatest physiographical importance because they give rise to the cirque which is one of the dominant forms of mountain glaciation.

Much of the field-work for this paper was carried out on the Cambridge Expedition to East Iceland, 1937. Grants towards the cost of this expedition were received from the Royal Society, the Royal Geographical Society, and the Worts Fund of Cambridge University. The members of the expedition wish to record their indebtedness for this financial assistance.

NOTES ON THE NORTHERN FRONTIER PROVINCE, KENYA

J. PARKINSON

THE geographical changes in the Northern Frontier Province of Kenya from mid-Tertiary times onwards have scarcely received the attention they deserve. For present purposes this great area is taken to include the Chalbi or Koronli desert, the country east of the Mathews range to the Italian Somaliland frontier, southwards to Isiolo, thence south-east to Bura on the Tana river, and thence eastwards along lat. 1° 10′ S. to Italian territory. The Ethiopian frontier on the north completes the outline.

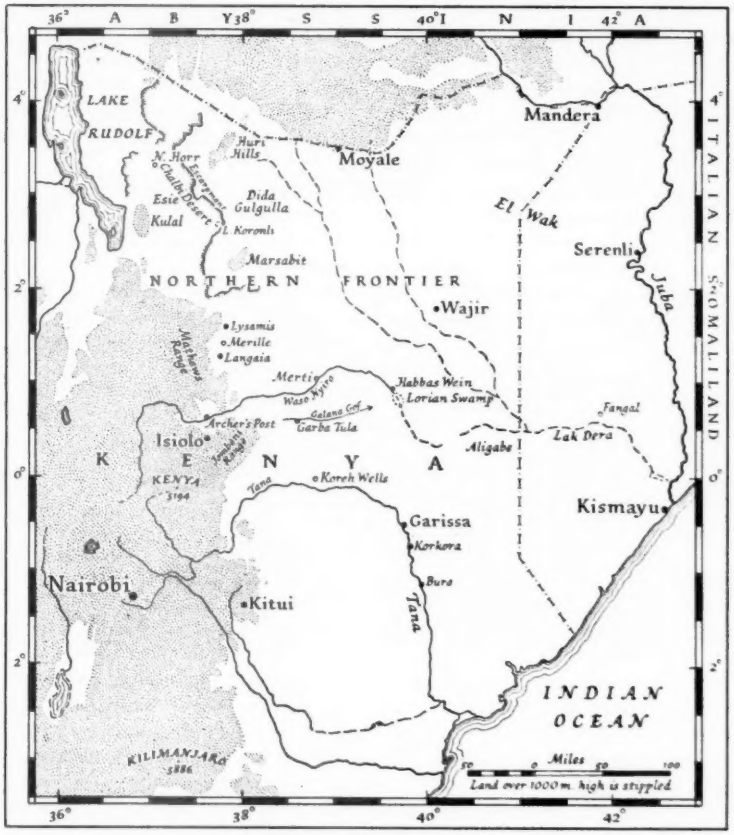
Kenya may be divided into Kenya proper, familiar to the tourist and settler, and the Northern Frontier Province, hot, parched, and dusty, to which access is barred unless by special permission. From the standpoint of practical utility, agriculture in the Northern Frontier Province is non-existent. The country, though geologically for the greater part very different, is singularly like British Somaliland in general appearance: its inhabitants, its water difficulties, and the sense of desolation it too often produces are points in common. Once a fertile land of lakes and great rivers it will, one fears, in the near future become a desert; it is already semi-desert and desiccation is to all appearances rapidly proceeding. With the exception of the Marsabit and Huri volcanoes and the Willeh hills in the north-east, the country is flat to slightly undulating, scantily furnished with trees, amongst which flat-topped conifers predominate, and tenanted by nomadic tribes, principally Somali and Boran, who possess huge herds of camels, sheep, and goats. Keeping them alive is a heavy drain on both grazing and water resources. The value to their owners is a matter of prestige and sentiment rather than of cash, since there is no market for these animals. In 1915, one small Indian shop or *duka* was established at Archer's Post on the Waso Nyiro and another at Moyale on the Abyssinian frontier; in 1938 they were common even in the most unlikely localities, and carry on a small trade in cloths, beads, cigarettes, matches, tinned salmon, and oil for lamps. Communications are maintained by a system of very bad dry-weather roads and wireless stations.

In 1914–15 the writer had the advantage of travelling through this country, except for the north-east corner, the Chalbi desert, and the district south of the Lorian. This first journey was accomplished by camel safari, which allowed leisure for observation, and was followed by a journey up the Juba river as far as navigation limits permitted, and by another from Kismayu towards the Lorian swamp as far as Fangal, in those days little-known country. These journeys occupied eleven months. East of long. 41° is now Italian Somaliland. In 1938 more extensive journeys were made by motor car, and in all about 7000 miles were covered.

In this enormous area the scenery falls naturally into three well-marked types: (1) hills of inselberg structure, formed from the Archaean rocks of the "Lower Basement Complex"; (2) the flat-topped sandstones of the Marehan Series [1] developed south-south-west from Mandera and Ramu and extending

[1] Glenday, V. G., *J.E. Afr. Ug. nat. Hist. Soc.*, March 1933.

eastwards to the Juba river near Serenli and northwards into Ethiopian territory; and (3) the featureless plain of grey silt and red granitic sand extending from the Merti plateau north-eastwards to Wajir and southwards across the Lorian swamp to the latitude of Bura on the Tana river and beyond. It is with the third part of the Province that this paper deals. The



Northern Frontier Province, Kenya

interest lies in the evidence of the striking geological changes that have taken place, as is proved by the sediments and terraces situated some distance from the banks of existing *laks* [1] and by limestone deposited in freshwater lakes where now no obvious drainage channels exist.

The main features of the country east of Marsabit have been referred to in the Report dealing with the results of journeys in 1914–15,[2] but recent

[1] *Lak* or *lugga*, a drainage channel containing water only in the wet season.
[2] Col. Rep. Miscell. No. 91. 1920. Cmd. 729.

traverses along the Chalbi desert and between the Lorian and Isiolo enabled the extent of the lava flows to be better appreciated than heretofore, as also the ancient lakes and former extension of the rivers. In the west doubtless the early Lake Rudolf included the Chalbi desert.[1] The interest of the volcanic episode lies largely in the differentiation into rocks of varying composition of the magma which produced the successive flows and the remarkable puy stage. The early extravasation of the plateau lavas (the western and natural end of which is the escarpment defining the Chalbi desert on the east) was succeeded by a volcanic phase of a Hawaiian type responsible for the elongated flat cones of Marsabit, Huri, and perhaps Esie, and to the south for the more Vesuvian type of Kenya and Kilimanjaro. These four principal volcanoes lie upon a zone roughly parallel with the Rift Valley to the west.

Very shortly after leaving Garba Tula in a westerly direction an extensive lake deposit is crossed, followed by a lava plain which extends almost to Isiolo, about 30 miles by road. From this lava field the range of puys forming the Jombeni range rises and probably marks a subsidiary line of weakness. In the streams (*laks*) cutting through the lavas well-marked sections of sediments in the banks form additional evidence of higher rainfall and more extensive erosion. Extinct hot springs, shown by limestone, partially silicified, forming terraces and mounds built up by the overflowing waters of the springs, are seen east-south-east of Garba Tula on the road to the Koreh Wells.

As perhaps the most interesting evidence of the changed conditions in the Province, the Merti plateau shows the reduced rainfall, the consequent desiccation of the country, and the shrivelling of the river system. A glance at the sketch-map will show the relation of the plateau to the Waso Nyiro. After leaving the neighbourhood of the Merti plateau, the river, not yet dry, bends to the south and enters the Lorian, now greatly shrunken. Compare the account of the Lorian given by Dracopoli in 'Through Jubaland to the Lorian swamp.' How far desiccation has proceeded since the book was written (1913) may be gathered from the remark (p. 303) that from Madoleh, where the river finally sinks into the ground, to Merti the "whole plain could easily be irrigated from the river." The "great agricultural possibilities" Dracopoli saw are now hopeless of realization. The present writer waded into the stream in 1914 until his passage was blocked by a mass of high reeds; in 1938 he was informed by members of the expedition that they had jumped across it. Now the land is an arid waste, swept by constant dust storms and dotted only with a few gnarled and struggling trees.

Emerging from the Lorian, the drainage channel is known as the Lak Dera and contains water only after heavy rains. The middle and upper courses of the river have been briefly mentioned in the Report referred to above. Dr. L. R. Cox has named a gasteropod found in a fragment of freshwater limestone, a few miles from the edge of the swamp as it now is. The snail is *Bithynia* (*Paranerita*) *humerosus*, v. Martens, a living East African species. Formerly the swamp must have extended some miles to the north, for a pit on rather higher ground put down 5½ miles from Habbas Wein bridge on the

[1] See Fuchs, V. E., "The geological history of the Lake Rudolf Basin, Kenya Colony," *Philos. Trans.* Ser. 3, vol. 229, 1939, p. 219. He considers that the water covering the desert was distinct from Lake Rudolf unless by overflow.

The Merti plateau

Sands composing the Merti plateau; the highest point is crowned by the lava cap

The Korkora Sands on the left bank of the Tana river

Puys of the Jombeni range, from the Garba Tula–Isiolo road

Chalbi Desert, with the lava scarp bounding it on the east

The Dida Gulgulla

Wajir road found massive gypsum at 4 feet. A careful survey accompanied by bores or pits would enable the size of the former lake to be ascertained; obviously it must once have been a very important sheet of water. It may be mentioned that the Galana Gof east of Garba Tula was probably a tributary of the Waso Nyiro or ran direct into the lake. Once it must have been a large river.

The Merti plateau rises sharply from the alluvial plain three-quarters of a mile north of the river, and is doubtless part of an old terrace formed at a time when the Waso Nyiro was a very important feature. It is about 600 feet above the plain, and the sands of which it is composed were probably accumulated during a period of elevation coinciding with one of excessive rain. The plateau is formed of compacted sand sufficiently solid to stand in a vertical face, very quartzose, and containing strings and occasional thin layers of quartz pebbles, which thickly strew the ground at the base of the cliff. Amongst them are a few well-foliated gneisses and pegmatites, accompanied not uncommonly by undecomposed cleavage fragments of orthoclase or an allied felspar indicating an earlier period of dryness. These are derived from the west or north-west. Locally the rock is almost an arkose, and below, forming the lower part of the cliff, is a mauve-coloured rather argillaceous sandstone. Traces of a lower terrace can be seen here and there. The plateau is covered by a thin lava flow that has doubtless preserved the sands from the denudation which removed the surrounding and presumably continuous deposits. Proceeding eastwards in the direction of Wajir there are extensive patches of pebbles on the flat ground, which are probably the remnants of the disintegration of a terrace similar to that of Merti, but unprotected.

The presence of lumps of lava on the slopes of the cliff is due to the undermining of the cap by the erosion of the softer sands below. The existence over a large area of so thin a layer of lava, about 8–10 feet thick, is remarkable; its extent as far as the writer is aware is doubtful, but a similar capping is conspicuous covering the crystalline rocks on the east side of the old safari route between Lysamis and Langaia, and though the intervening country, 70 miles in a direct line, has not been traversed by me, it seems probable that the lava is continuous. Distinctly later than these flows are the puys [1] west of Lysamis showing only the slightest of erosion features and greatly resembling those forming part of the Jombeni range, east of Isiolo.

Similar proofs of a former great extension of the river system preceding a period of elevation are found near the Tana river, 10–12 miles south of Garissa. The locality is known as Korkora, and the alluvial deposits may conveniently be known as the Korkora Sands. An excellent section of these beds is to be seen along a branch road leading east from Korkora about $15\frac{1}{2}$ miles south of Garissa and half a mile approximately from the left bank of the Tana. It consists of red and grey sands topped by a thin layer of quartz pebbles. Locally the sands when slightly clayey are very gypsiferous. The quartz pebbles are well rounded, of ivory, pink, or purple quartz, and seldom larger than a hen's egg. Lava pebbles are unusual, but small pieces of fresh-looking pumice were found by searching. In general terms the sands resemble closely those of the Merti plateau, the likeness being heightened by the frequent

[1] See Report Cmd. 729. 1920. App. C. Fig. c.

occurrence of angular fresh cleavage plates of felspar, amongst which microperthite is fairly common. These beds are also exposed 22 miles north of Bura and stretch back 4–6 miles at least from the present bank, and similarly on the right or western bank, as seen along the Kitui road.

Taken as a whole the plain east of the Tana river as far as the international frontier is featureless and covered by thorn scrub, often very dense. Eighty-two miles north-east from Garissa at Aligabe and about 10 miles from the Italian territory, a clearly defined terrace consisting of brown, well-bedded soft sandstones is passed about 600 yards south of the *lak*. These sediments become red and laterized on the lower ground and frequently show an appearance of brecciation; angular grey fragments of hard clay are closely scattered in a chocolate-brown rock with bluish-black iron segregations. The shells of freshwater snails, the epidermis still present in some cases, occur locally in profusion near the *lak*. In regard to the western part of the area, there is little to add to V. E. Fuchs's recent Memoir on the Lake Rudolf basin. The Chalbi desert is bounded on the east by the edge of the lava flows, which the writer believes are of the same age as the lava flows of the Dida Gulgulla, and form a base for the flat conical masses of Huri and Marsabit.

Motoring westwards across the desert for a dozen miles or so the featureless expanse of sand gives place to low hills and dunes with scattered thorn bushes half buried by the slowly invading enemy. This struggling vegetation becomes more profuse and less stunted to the west in the direction of Esie.

Clearly the onset of desolation comes from the east in this locality. Going northward to Northern Horr the same encroachment is seen, with all stages of obliteration from dead sand-scarred stems to dwarfed shrubs whose slow burial has only just commenced. Lake Koronli, on the southern edge of the desert, which figures on many maps, was a shallow dried depression when seen, but no doubt had recently contained water. In August of last year vast herds of camels, sheep, and oxen belonging to the Sakuye were moving down from the north towards Lake Rudolf owing to failing supplies in their own country. The problem is the old one of overgrazing and the possibilities of solving it are extremely poor. On the whole there is no great depth of soil over the Province except for coarse sandy alluvium along the dry river banks, while near El Wak and the Lorian the water is gypsiferous, and pits in the sands of the Koronli desert showed at a depth of a few feet an extremely brackish fluid permeating sandy clays. Lord Hailey's remarks on the "widespread erosion due to overstocking . . . in parts of the arid Northern Frontier District"[1] are well worthy of attention.

[1] 'An African survey,' pp. 1110–11.

REVIEWS

EUROPE

GEOLOGY OF LONDON AND SOUTH-EAST ENGLAND. By G. M. DAVIES. *London: Thomas Murby and Co.*, 1939. 8×5 *inches;* viii+198 *pages; illustrations and maps.* 7*s* 6*d*

If the author's aim has been primarily to create a wider interest in the geology of one of the most interesting regions in the world, he is to be congratulated upon the production of a work so admirably adapted to this end. The reader who has no previous knowledge of geology need not fear to embark upon its pages. In addition to this however the book fulfils another purpose. Its pages are packed with so much accurate and well-indexed information that those who already take a serious interest in the geology and geography of south-east England will wonder how they have managed without it. At the beginning of the present century the student of English geology found that the geological history and structure of the south-east were comparatively straightforward: there were the London and Hampshire basins and the Weald, with their strata arranged in synclines and anticlines, described and explained with confidence in the text-books. The intervening period however has seen a vast amount of detailed study in the area, and the accounts of it, in technical language, are scattered. References are here given to nearly three hundred papers, books, and maps; and this bibliography alone will be of great value to geologists and students.

South-east England, for the purpose of this book, extends in the south from Kent to the Isle of Purbeck and northwards to the Wash. There is a simplified geological map of the area (1 inch to 25 miles) which serves also as an index to the ¼-inch and 1-inch Geological Survey maps. The author very wisely commences with the most recent deposits, relating to the periods during which Neolithic and Palaeolithic men inhabited these parts, that is, the alluvium of our present rivers and the submerged forests around the coast, the Pleistocene river gravels and the boulder clay and gravels of the Glacial Epoch. Thence the reader is taken step by step backwards in geological time through the Tertiary formations of the London and Hampshire basins to the Cretaceous and Jurassic rocks which form the Downs and the Chiltern Hills, the Weald, and the hills and vales of Northampton and Rutland. So far can we travel by a study of the strata which are exposed at the surface within the area. Then by a leap in geological time the reader is introduced to the Palaeozoic rocks, including coal measures, which form the deep-seated foundations of London and the south-east. Still other rocks are discussed in the interesting chapter on "The stones of London," including those of Westminster Cathedral. At appropriate places geological processes such as erosion and earth movements are explained so that the book becomes almost a text-book of geology.

Geologists will welcome in particular the chapter dealing with the most recent invasion of these parts by the sea in Pliocene times, and that devoted to "The Palaeozoic floor" with its map and four-page table of all the deep borings in the area. So much has been learnt about both these subjects in recent years that these up-to-date summaries of our knowledge with bibliographical references are specially useful. A separate chapter is devoted also to "Wells and springs, streams and rivers." Liberal use has been made of illustrations in the text—actual and diagrammatic sections, sketch-maps, drawings of typical

fossils, etc.—and of tabulated data. Finally there are five photographs of coastal and inland scenery chosen to illustrate geological features.

One rarely finds a book so well adapted to the needs of the general reader and yet so indispensable to the serious student, and this whether he is interested in the general geography or specifically in the geology of the region. C. C. F.

WEST COUNTRY (Somerset, Devon and Cornwall). ("The face of Britain" series.) By C. HENRY WARREN. *London: B. T. Batsford*, 1938. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* viii + 120 *pages; illustrations.* 8*s* 6*d*

This is an attractive book, with a long series of fine photographs, many of which render elaborate architectural detail with wonderful clarity, *e.g.* Exeter Cathedral, St. Saviour's (Dartmouth), Wrington church, Wells Cathedral, and Weston Zoyland church. Among scenic effects may be noted the pictures of cliffs at Tol-Pedn-Penwith, Cheddar Gorge, and Dunkery Beacon from Grabbist Hill. The author rightly deprecates tiresome rhapsodies about scenery, and meets modern requirements by supplying information on geology, meteorology, and ancient history. He is however unfortunate as to Roman origins, *e.g.* "A.D. 43 when Julius Caesar landed on these shores"; the Romans "erasing the existing culture everywhere except in the extreme north and west." Of Cornwall he writes, "Certainly no unequivocal evidence of the Roman occupation has been found there." Roman habitation sites in Cornwall, if few, are authentic: *e.g.* Tregear, Harlyn, St. Minver, and Bosence. A great number of Roman coins, found mostly west of Truro, indicate the working of the tin mines *c.* A.D. 250. A series of Roman milestones also is significant.

The style is occasionally grandiloquent, *e.g.* at Wells, the "most lyrically triumphant church." S. E. W.

LANDSCHAFT UND MENSCH IN DEN HOHEN TAUERN: Beiträge zur Kulturgeographie. By RUDOLF PREUSS. *Würzburg-Aumühle: Konrad Triltsch*, 1939. $9\frac{1}{2} \times 7$ *inches;* xvi + 326 *pages; diagrams and maps. M.*12

Dr. Preuss has written a monograph on the population and pastoral activities of the Tauern, chiefly in their demographic aspects; and has also completed some extremely minute and detailed investigations into the process of settlement in two valleys. Instead of publishing this original work as a monograph and as articles, they are combined with material drawn from library research in a book having the outward form of a treatise. As might be expected, it has proved impossible to fuse completely such diverse products, and the book is inwardly far from homogeneous.

In the first fifty-five pages the habitat is reviewed in its physical and biological aspects, and, as a start for the section on "The evolution of the cultural landscape," we skim over the prehistoric and Roman periods. The secondary valleys of the Tauern were penetrated first by Slavs (A.D. 600–800), the advent of Germans being delayed till the ninth century. The complex of field and place names in these valleys may be analysed into two groups, Slavonic and German; and the latter names may be assigned by further analysis into several groups each appertaining to a period between 800 and the close of the Middle Ages. This method of place-name analysis was first employed by Bidermann some sixty years ago, and since the War it has been taken up again by several workers, including Dr. Brandenstein and Dr. Preuss himself. Dr. Preuss's work does not cover more than a fraction of the Tauern; his next few chapters (to p. 79) dealing with the progress of settlement down to the end of the Middle Ages are concerned almost exclusively with the Möll valley on the south-eastern flank of the mountains. Then, after a few short chapters bringing the

story of settlement down to the present day, we are presented with an exhaustive analysis of field names in the Möll valley, and of the arrangement of parcels of land around chalets and their outbuildings. This kind of research can be combined with the older kind of place-name analysis, and itself constitutes the special contribution to research on the evolution of Alpine settlement pioneered by M. Sidaritsch, and taken up by J. Schmid, the author, and others. It is possible here to give only the briefest summary of their findings.

The Slavonic penetration saw the foundation of small hamlets along the valley-bottoms, very frequently on the upper slopes of alluvial cones. Domestic animals of these original settlers were pastured in forest clearings, and field names derived from Old Slavonic (*e.g.* Dambra=oak-groves) around these villages are confirmatory. The Slavs appear not to have made use of the Alp pastures, and as a rule chalets in these earliest settlements do not possess private holdings of Alp pasture to-day. Another characteristic is the high degree of fragmentation of the land around the village; patches are small and much intermingled. When the first Germans arrived there was still land available along the valley-bottom, and many early German villages were on alluvial cones like the Slavonic, and even resemble the latter superficially in the grouping of houses. But as a rule in the German villages the chalets are more spaced out, so that each stands in a fairly large plot of ground. Furthermore, the permanent meadow, down by the river, perhaps once held in common, is now divided into narrow strips, like those of an open-field village in central Germany.

German immigration, once begun, continued steadily for four centuries. As time went on, the lowest ground came to be fully occupied. Settlement had to extend up the slopes towards the upper limit of forest. This stage saw the rapid clearance of forest, and the full utilization of Alp pasture. Feudal lords, whose authority had now extended into the valleys, established dairy farms (*Schwaighöfe*), often high up the slopes, maintaining large herds of milch cattle. Thus an economy was practised differing much from that of the older settlements, yielding a very substantial annual revenue in the shape of cheeses. Farms originating in this way very often hold even to-day a block of Alp pasture.

The later phases of settlement have already been worked out, and it is unnecessary to occupy space on the subject here. In the last sections Dr. Preuss provides us with a workmanlike account of house-types in the Tauern, and his demographic work (noticed above) on population and pastoral activities.

J. H. G. L.

TIROL, VORARLBERG . . . HANDBUCH FÜR REISENDE. By KARL BAEDEKER. *Leipzig: Karl Baedeker* [*London: George Allen and Unwin*], 1938. (40ste Auflage.) $6\frac{1}{2}\times4$ *inches;* lvi+348 *pages; maps and plans. M.*8.50 [11*s* 3*d*]

LET'S GO TO THE DOLOMITES: a traveller's companion. By L. M. DAVIDSON. *London: Frederick Muller,* 1938. 7×4 *inches;* 172 *pages; illustrations and sketch-map.* 5*s*

Even Baedeker has not been able to remain indifferent to the political changes of recent years. In 1842, when Herr Baedeker first told his readers how best to explore the mountains and valleys of Tirol, there was no German Empire and Tirol itself formed part of the ancient Habsburg dominions comprised within the Austrian Empire: the first edition of his guide bore the title 'Handbuch für Reisende durch Deutschland und den Österreichischen Kaiserstaat.' In former editions North and South Tirol were described within the covers of a single volume as though they still formed a political entity. The preface is

silent about the omission from the present volume of any mention of the other half of the ancient Countship of Tirol lying beyond the Brenner and within the Italian frontier. Otherwise there are few changes. The introduction has been enlarged by six pages and the several contributions composing it largely re-written and brought up to date. The new road-maps on a scale of 1 : 500,000 will be welcomed by pedestrians and motorists alike, and the latter will also find that the hints contained on pp. xxiii–iv repay their attention. In one respect alone it has been impossible to maintain the accuracy of previous editions. Owing to the substitution of the *Reichsmark* for the Austrian *Schilling* prices can only be regarded as approximate. In general however it may be said that the fortieth edition maintains the high standard of its predecessors.

There can obviously be no comparison between the encyclopaedic Baedeker and Miss Davidson's gossipy little guide. Nevertheless it is surprising how much useful information about hotels, walks, wines and food, and even wild flowers, she has managed to compress into so small a space. It was perhaps difficult to avoid scattering much of this information rather haphazardly across the pages. Its usefulness could however have been enhanced at the cost of a larger index. An equally serious omission is the absence of even a small map of the Dolomite region and also of any mention of the approximate prices that have to be paid in different classes of hotels. The spelling of place-names is not always accurate—"Vintsgau" for "Vintschgau," for example—and the proofs might have been more carefully read. I. F. D. M.

THE CALL OF THE SIREN [Naples to-day and yesterday]. By ALEXANDER POLOVTSOFF. *London: Selwyn and Blount*, 1939. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* 256 *pages; illustrations.* 10*s* 6*d*

Medieval Naples is remote, and even the Renaissance did not leave its impression there as deeply as elsewhere; but since the critics, as M. Polovtsoff points out, have ceased to regard baroque as a personal insult, Naples has diverted to itself some of the interest in art and architecture hitherto reserved for the north of Italy. Probably the author has come near solving the problem of the city's backwardness when he remarks that Naples has always been poor; thus it was left to seventeenth and eighteenth century despots to do what the merchant oligarchs had earlier done for the city states of Lombardy and Tuscany. For those who visit Naples intending to take an interest in other than scenic beauties M. Polovtsoff's chapters on churches, palaces, museums, and painting can be recommended. His may not be, as Mr. Sitwell claims in the introduction, the only adequate book on the city; it has however the merit of a sympathetic approach, unmarred by sentiment. The only pity is that the author did not stick to his last—to the statues in the Sansevero chapel or the staircase in the Certosa di S. Lorenzo—but was twice persuaded to make a tedious excursus into history. J. P. H. M

YUGOSLAVIA: a guide book approved by the Official Tourist Department for Yugoslavia. By MURIEL CURREY. *London: Chatto and Windus*, 1939. 8×5 *inches;* vi+240 *pages; illustrations and map.* 7*s* 6*d*

This is not a book of travel reminiscences. It aims at being useful rather than entertaining, and though in so few pages there is not perhaps much that is new to be told about Yugoslavia, the information is well marshalled and imparted in business-like fashion. Two chapters are given to general and historical matters, with detail sufficient about travel, food, festivals, societies, etc., to make them of real use. The reader is then taken on a series of tours from Slovenia (here details are given for mountaineers) to south Serbia, in which the

chief places of interest are described. Belgrade and Dubrovnik get about eight pages each; other places only a few lines, the information being mostly limited to historical monuments. Space is found for reference to the largely forgotten exploits of Captain Hoste at Kotor and elsewhere during the Napoleonic wars. The book as a whole might be criticized for concerning itself with cities and monuments rather than with country and people. It is handy in format, but might have been served with a better map. There are traces of hasty proof-reading, but with place-names care has been taken; though for some reason Slawon*ia* replaces Slavon*ia*, which is conventional as are the other names of countries and regions, or Slavon*ija*, which is correct. J. P. H M.

ASIA

PETRA: the rock-city of Edom. By M. A. MURRAY. *London: Blackie and Son*, 1939. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* xiv+210 *pages; illustrations and sketch-maps.* 10*s* 6*d*

Dr. M. A. Murray has written a popular book on Petra. Having spent a number of weeks there as a member of the staff of the British School of Archaeology in Egypt, she writes from first-hand information. The "rose-red city, half as old as time," is neither rose nor red, nor half as old as most of the antiquities in the ancient Near East. What makes Petra unique is its position, its water, its monuments, and its history. All these aspects are treated in the book at sufficient length and with sufficient clarity to give the new-comer a good deal more than a tourist's idea of the significance of the place, although he will find some welcome instructions on how to get to Petra, and what to wear there. It is also an excellent idea to describe the present inhabitants of Petra, and to give some details of the fauna and flora. The author is at her best when dealing with the ancient and modern legends associated with the site. The monuments of Petra are sufficiently described to whet the desire of the reader actually to see them. It is pleasant to note that all the buildings at Petra are not considered to be temples or tombs, but that many of them are recognized as dwelling-places. The reader will find much solid information also in the chapters on the Nabataeans, and the trade of Petra, and amusement in the chapter on the trials and troubles of an excavator.

In the chapters on Edom, the Edomites, the religion of Petra, and also in the chapter on the Nabataeans, Dr. Murray enters a controversial field in which her footing is not very firm. We know much more about the civilization, organization, and boundaries of the kingdom of Edom than one gathers from this book. Furthermore, we are long past the day when the Nabataeans can be described merely as traders and Petra as a trading centre. The Nabataeans became also excellent farmers, and extremely capable water engineers. The area they occupied in southern Transjordan is dotted with villages and towns set in rich agricultural districts, which they developed with great skill and energy. We also know much more about Nabataean deities and Edomite gods than the reader might gather from this book. The Edomite God named Edom exists only in this book. There was however one named Qaus, whom the Nabataeans adopted. In addition to Dushara, the Nabataeans worshipped a whole pantheon of Syro-Hellenistic gods, represented by statues and bas-reliefs now being found in increasing numbers in Transjordan. The idea that the Nabataeans represented the deity only through a rude stone block can no longer be maintained. Dr. Murray comments on the lack of forests in the Nabataean kingdom, but the hills of Edom were still covered in part with great stands of oak, and particularly near Petra, as late as the last World War.

In small scope however much material of great interest has been compressed.

The text is illustrated with some excellent photographs and two sketch-maps, one of Palestine and Transjordan, and one of Petra. A selected bibliography and index give the book further value to the general reader. N. G.

INDIA'S NORTH-WEST FRONTIER. By Sir WILLIAM BARTON. *London: John Murray*, 1939. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* xiv + 308 *pages; illustrations and maps.* 10*s* 6*d*

During the last few years a minor war has been raging in Waziristan, a mountainous country about two-thirds the size of Wales, where the Government of India has put as many as 40,000 British and Indian troops in the field. Perhaps few people in this country realize that this campaign is part and parcel of a much greater problem, which is in some ways as grave to-day as it was during the First Afghan War exactly a hundred years ago. Peace in that belt of unadministered tribal territory over 1000 miles long, which forms the frontier between India and Afghanistan, is as vital an imperial interest as ever it was.

Nineteen years spent as an administrator in the Frontier Province give authority to Sir William Barton's account of the history of the frontier lands, of their administrative problems, and of their social and economic conditions. It would be difficult to detect inaccuracies in the mass of information which the author conveys about the territory which he knows so well, though his appreciation of the chief problems on the Afghan side of the boundary is less sure. If accuracy and first-hand knowledge make this an important work for the student, such qualities cannot by themselves make an interesting book, or one which could be recommended to the general reader as a clear and straightforward guide to a complicated and sometimes baffling subject. The book as a whole reads like a series of "sketches and episodes." The history of a hundred years is scattered among the rest of the material; the geographical background is sketched here and there, but chiefly by means of statistics, and hardly with a vivid pen; the style frequently reminds one of an administrator reporting to his Government on events, in the knowledge that his correspondents are as familiar as he is with the background of what he describes. If a book of this kind is to be intelligible to the general public, the ignorant may claim some indulgence. Unfamiliar terms and names should be defined and explained at their first appearance, and knowledge must not be assumed of episodes of which an account is given in a later chapter. An adequate map is an essential feature of such a book; the two rough sketch-maps show no relief whatever, and a great many places constantly referred to in the text are not marked upon them.

E. B.

LANGUAGE HUNTING IN THE KARAKORAM. By E. O. LORIMER. *London: George Allen and Unwin*, 1939. $9 \times 5\frac{1}{2}$ *inches;* 310 *pages; illustrations and map.* 12*s* 6*d*

The officials who go back to India after their service is done are very few. Colonel Lorimer set out again, accompanied by his wife, for the frontier region of India ten years after his retirement. The incentive to the journey was a scholarly interest in the language of the Hunza people. His service had brought him into contact with most of the languages of the North-West Frontier district; it had been his hobby to study the grammar and relationships of such languages as Shina, Khowar, and Burushaski; his return was to complete his observations on the latter, the language of Hunza.

Mrs. Lorimer's book is a record of the day-to-day events of this interesting experience. It is, as it were, an *hors-d'oeuvre* to the book which we hope will soon come from Colonel Lorimer's hand. Taken by itself it is therefore tantalizing,

because nowhere has she allowed herself to poach the rich preserves of her husband's notebooks; whenever the text leads her towards any of the many fascinating questions of the origin of the Hunza people or their language she faithfully turns aside at the last moment. What we experience therefore is an introduction on a personal level to the hill people of Hunza. We accompany these determined and experienced travellers over the Burzil pass to Gilgit and thence to the glorious vale of Hunza; we are shown the day-to-day progress of the work while they are settled in Aliabad; and we come directly into contact with the individuals and families who live there.

The book is clearly the work of an experienced writer. But there are two motifs that jar, both probably springing from the intellectual vigour which inspired the journey and the book. On the one hand there is an implied superiority of experience and background demonstrated at its most exasperating when the reader, approaching the Burzil pass, is offered a bouquet of erudite quotations from poetry in four (European) languages. On the other, there is a constant nagging at European culture and its deficiencies by comparison with the culture of the Hunzukuts. The roads of Hunza, the author claims, are safer than our murderous motor roads; and the people of Hunza, on another page, are better educated than the products of our costly schools, and so on. If an author is to attempt to assess the value of a foreign culture he should not dismiss the whole tradition of Europe with a sneer. But our author perhaps disarms criticism by her appropriate choice of a couplet from Goldsmith: " 'Tis yours to judge, how wide the limits stand Between a splendid and a happy land." She will have it that there, at 8000 feet in a remote part of the Himalaya, the blossom of the apricot and the tinkle of the goat-bells reflect not a splendour which passes far above the heads of all but a few, but a happiness which is shared by the humblest. M. A. S.

SOUTH OF THE CLOUDS: a winter ride through Yün-nan. By GERALD REITLINGER. *London: Faber and Faber*, 1939. 9 × 5½ *inches;* 328 *pages; illustrations and map.* 15*s*

This is an entertaining and picturesquely written story of a journey through Yunnan. The author travelled by the French railway to Kunming (Yunnanfu) and thence *via* Tali northwards to Likiang. Here he left the beaten track and made an excursion into the mountain mass which lies inside the hair-pin bend of the Upper Yangtze, penetrating the great gorge of the river where it cuts its way through what the author terms "the true eastwards extension of the Himalaya." Back in Likiang, he retraced his steps to Tali, turned thence westwards to Tengchung (Tengyueh), and emerged in Burma by the road to Myitkyina. From a geographical point of view the journey was along well-trodden trails, except for the excursion through the Yangtze loop.

Mr. Reitlinger spins a lively yarn, and travels in the right spirit, with little baggage, living on the country, and appreciating the free and easy atmosphere of Chinese local life. In the back-blocks of south-western China the war with Japan is something quite remote. But the story is that of a globe-trotting traveller; and the occasional aberrations in the transliteration of Chinese place-names and words and a certain looseness in reference to well-known localities and facts will probably jar on a reader versed in the lore of the West China borderlands; as for instance when he is informed that *tzumba* is "the roasted green wheat of Tibet" or, later on, that it is made of millet picked green.

But it is perhaps ungracious and unnecessary to stress inaccuracies arising from a lack of local knowledge. The author warns us in his introduction that he does not propose to write as an explorer and scientific traveller, but as

one who journeys for pleasure and records his experiences for entertainment. Read in the same carefree and easy mood as that in which the author travelled, the book should afford interest and entertainment to a public unacquainted with China's western borderlands. It is well illustrated and is supplied with an adequate index and map. E. T.

AFRICA

RACES OF AFRICA. By C. G. SELIGMAN. (The Home University Library, 144.) Revised edition. *London: Thornton Butterworth*, 1939 (*first published in* 1930). $6\frac{1}{2} \times 4$ *inches;* 256 *pages; maps.* 2*s* 6*d*

This book, which is a compact and concise account of the native races of Africa, is an admirable introduction to the subject and, in spite of much necessary condensation, is presented in very readable form. A useful introductory chapter explains the basis of classification and points out the difficulty of this task owing to the vastness of the continent and the consequent gaps in our knowledge. Linguistically there is more known, perhaps, and although language is no safe guide to race it has to be used to a large extent in Africa. The remaining nine chapters deal with the Bushmen, together with Hottentots and Negritos, the true Negros, the Hamites, Half-hamites and Nilotes, the Bantu, and the Semites. Each race is placed in its geographical setting and much interesting information is given.

Additions to the original edition published nine years ago include a note on the importance of the Boskop skull discovered in the Transvaal, an account of the Pygmies as described by Paul Schebesta, and a slight alteration in the classification of the linguistic stocks of the Guinea Coast. The bibliography has been enlarged, but it is unfortunate that Mrs. Hoernlé's work is omitted in the revised text, considering the references to it in Chapter II. K. R.

THE INDUSTRIALIZATION OF SOUTH AFRICA. By G. C. R. BOSMAN. *Middelburg and Rotterdam: G. W. Den Boer*, 1938. 9×6 *inches;* viii + 243 *pages; illustrations and map.* 10*s* (*unbound* 8*s*)

The economic life of South Africa like that of Canada, Australia, and other young oversea countries, developed under the influence of Europe. For some two centuries South Africa was in the main an area of subsistence farming with a small amount of export of raw materials to the home country and only minor manufacturing industries. The mineral era which began about 1870 brought widespread social and political changes and, though it stimulated agricultural output, did not materially change the nature of agriculture and pastoral exports. The actual manufacturing era of South Africa did not develop until the years of the Great War. In this thesis the author discusses at length the possibilities of the future of manufactures in the light of raw materials, power, and markets. Coal resources are great and will be a vital factor in the future development. Good iron ore is plentiful; other metallic ores are less important. Labour is a serious problem and will have to be much cheaper if an export of manufactured goods is to be possible on a large scale. This would however entail a lowering of the standard of living, a problem which the author also discusses. He seems to foresee a future in manufactures mainly for the internal market or, in the utilization of agricultural products, for limited foreign markets. The export of primary products however will always entail a large import trade. This necessity should check excessive industrialization. The author insists on the need for a sound agricultural policy and dwells on the danger of neglecting agriculture in the interest of mining and manufactures. Irrigation and more dry farming

are needed. Maize production could be increased, though South Africa could probably never enter the world market in wheat. The thesis is closely reasoned throughout with much statistical matter: the arguments are well marshalled even if the style is heavy in places. Though much of the theme is economic it has important geographical bearings. R. N. R. B.

NORTH AMERICA

THE LAW MARCHES WEST. By Sir CECIL E. DENNY, Bart. Edited and arranged by W. B. CAMERON. *London: J. M. Dent and Sons*, 1939. 9×6 *inches;* xvi+320 *pages; illustrations and sketch-maps.* 15*s*

THE VANISHING FRONTIER: a saga of traders, Mounties and men of the last north west. By PHILIP H. GODSELL. *London: Robert Hale*, 1939. 8½×5½ *inches;* 286 *pages; illustrations and map.* 12*s* 6*d*

These two books represent very different attempts to describe life during the settlement of northern Canada; the first during the last thirty years of last century, and the second during a similar period previous to the present day.

Sir Cecil Denny was one of the original officers of the North-West Mounted Police, which later became the more famous Royal Canadian Mounted Police. He took part in the historic trek which the newly completed force made in 1874 from Toronto, where they had been formed, to the North-West Territories where their duties lay. He stayed only eight years in the force, but he continued in the country as Indian agent for the Cree and Assiniboine tribes, and was one of the signatories to the treaty made in 1877 between the Canadian Government and the Indians. Perhaps his greatest service was done during the Riel rebellion of 1885, when his influence was effective in keeping the southern Indians out of the rebellion.

Sir Cecil Denny wrote well; his account is detailed and well-informed, and should prove a valuable addition to this portion of the history of Canada's northern development. Many of the illustrations are of great interest, since they are reproductions of early photographs of the first Mounted Police posts, but the map opposite p. 57 is very poor indeed, being illegible in many places. It is a pity that such a blemish should spoil what is otherwise a very well-produced book.

Mr. Godsell is obviously more of a professional writer and has chosen to tell his autobiography in narrative style. His account describes the development of the Territories from the point of view of a trader, since he was for many years a member of the Hudson's Bay Company. While he appears to give a more intimate description of the Indians because of his personalities, his book is actually much less interesting than Sir Cecil Denny's, for the latter had obviously a greater knowledge and understanding of their problems. Mr. Godsell's style is flowery; he would like to persuade us that years of living alone among half-breeds and Indians have made him a man of simple language, but his use of the stock phrases of description bespeaks the professional writer. This is really a boys' book of adventure and of no importance to the serious student. The map, and the photographs, many of which are from official sources, are good, but the bear facing p. 92 seems almost too good to be true.

J. W. W.

MEXICAN MOSAIC. By RODNEY GALLOP. *London: Faber and Faber*, 1939. 9×5½ *inches;* 300 *pages; illustrations and map.* 15*s*

This is a book to be kept by every one interested in Mexican folk ways. Mr. Gallop's previous work, dealing primarily with traditional dances and songs in

Europe, permits him to claim the modest title of folk-lorist; but if he is not yet an ethnographer he is undoubtedly of the stuff from which good ethnographers are made.

The ground covered in search of Mexican tradition, during a series of journeys some of which took him as far afield as Oaxaca, Michoacan, and Huehuetla, included regions and tribal groups rarely seen by outsiders. The author discovered more than one example of the magic wooden gong, *teponaztli*, whose retention and use are secret. Few have ever reached Europe, although the British Museum possesses three.

Many visits were made to Otomi and Tarascan villages, usually for the purpose of recording dances and other ceremonies of ancient observance; among them, the "flying game" still performed by Totonacs and Otomis. The author shows clearly the vitality of pre-Cortesian beliefs and customs, especially in connection with medicine and agriculture; and his descriptions of mountain and valley, cultivation, forests and rivers, houses and costume complete a valuable picture of the way of life in the regions visited.

Mr. Gallop liked Mexico and the Mexicans, and in spite of frequently difficult living conditions during journeys has no word of complaint; the wilder and less comfortable the region, the more he and his companions seem to have enjoyed their experiences. The photos are excellent, drawings in the text striking and often extremely decorative. Typography and presentation are alike excellent; glossary, index, and map are what the reader needs. L. E. J.

THE CIVILIZATION OF THE AMERICAS. Lectures (Los Angeles, 1938) arranged by . . . Committee on International Relations. *Berkeley, Cal.: University of California* [*Great Britain and Ireland: Cambridge University Press*], 1938. 8 × 5½ *inches;* viii + 174 *pages.* 7*s* 6*d*

Of these six lectures much of necessity is generalization, sometimes helpful but not always profound. Certain ideas however are of interest, for they are common to all the speakers. Though the title covers both the American continents, it is noticeable how important is the rôle assigned to Central America, especially to Mexico, in the future of American civilization. Professor Beals recalls the high level attained by the civilization of pre-Conquest mid-America, and the spread of its influence north and south. The Conquest broke this central link, leaving the two continents looking to the Old World rather than to each other. The development of an American civilization would thus depend on restoring the link, and with this is bound up the utilizing of the latent resources of the Indian. This, as Professor Simpson explains, was the chief task facing the Spaniards, who devised the *repartimiento* to educate the Indian in the wage-earning ideals of his masters. In the synthesis of Indian and European now taking place in Mexico Professor Beals hopes to descry the beginnings of a civilization founded on "the democracy of the agricultural village," in which individualism will find its place, subdued by "the strong sense of community values stemming in part from the collective responsibility of the Indian society." Professor Priestley, regarding the history of the Americas as a continuous battle against exploitation by monopolist groups in both the Old and the New Worlds, likewise stresses the importance of the struggle for survival of an indigenous civilization in Mexico. On the other hand Professors Alsberg and Fitzgibbon seem to look on South and Central America mainly as a safe investment for surplus capital, and the latter regards the two continents as economically complementary. Somewhat apart from these themes is an interesting paper by Professor González on culture contacts between North and South, which were scantier in the century following Independence than is mostly believed. J. P. H. M.

CENTRAL AND SOUTH AMERICA

VOODOO GODS: an inquiry into native myths and magic in Jamaica and Haiti. By ZORA HURSTON. *London: J. M. Dent and Sons*, 1939. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* x+290 *pages; illustrations.* 15*s*

Miss Hurston was the recipient of a Guggenheim Foundation Fellowship which resulted in the travels in Jamaica and Haiti herein described, and it is hoped that the real scientific results will in time be published. The present book is unscientific in approach, though very far from fictitious in content. It should not however be added to the string of purely sensational writings upon the subject of West Indian folklore and animism. Apart from her merit as a writer, Miss Hurston has unhesitatingly tackled the knotty problems that are always encountered in this field. She is herself of the Negro race and the first woman to describe her own experiences; both these facts are essential to the observations and understanding of much in Haiti and, to a certain extent, in Jamaica. Her book is a compendium of all the stories, accounts of experiences, and descriptions of scenes at present current in these countries.

Voodoo—or as it should more properly be spelt, Vaudun—is the degraded progeny of African Juju. In one form or another, together with its attendant folklore, medicine, and arts, it is spread over the New World from Brazil to the United States. It assumes wider proportions in Haiti than elsewhere, where it is the national religion. Music, dancing, medicine, and religion together constitute African Juju and Haitian Vaudun. In Africa however Juju is the law and, with very few minor exceptions, beneficial to the communities whose ancestors created it and whom it now serves. In Haiti it is "against the law" and though predominantly harmless, is sometimes anti-social and dangerous. That it is no longer the law of the community and is now administered by private individuals, often for profit, rather than by autocratic bodies for the benefit of the tribe, renders it a dangerous weapon in the hands of the irresponsible. Juju comprises a great body of practical knowledge of which we know nothing. The Haitian has received some of this from his African ancestors, but with none of the rigid tribal control.

Miss Hurston describes vaudun practices and ceremonies both in Jamaica and Haiti, and prefaces both parts of her book by some account of the social and political conditions in the two countries. This is a wise procedure, for much of African tribal, political, and social life is reflected in that of the West Indies beneath the outer shell of European law and government.

Those acquainted with West Africa will meet many old friends in these pages. Not only the drum-music, dances, ceremonies, and the characters of the divinities but even the names of many of them—Damballa, Sobo, Dahomey, Ibo, and so forth. The fact that neither the true African renderings of these words nor the origins of what they signify are mentioned bears out the contention that any study of West Indian vaudun without previous knowledge of West Africa is scientifically useless, for the Haitians themselves are quite unaware of the significance of all but a fraction of what they do.

The descriptions of ceremonies in Haiti are lucid and accurate, though they show evidence of special embellishments provided for the benefit of the visiting foreigner. The spelling of Haitian names and words must of necessity be phonetic, for creole has never been officially transliterated; nevertheless an obviously incorrect rendering sometimes results, as with the lizard, the mabouya, which here appears as "mabolier." The Jamaican lizard is known locally as the "galliasp" and not "gallowass," and it should be pointed out that in life neither of these lizards is poisonous. I. T. S.

AUSTRALASIA AND PACIFIC

THE NATIVE RACES OF AUSTRALASIA, including . . . Indonesia. A selection of passages from the notebooks of Sir JAMES GEORGE FRAZER. Edited by ROBERT ANGUS DOWNIE. (Anthologia anthropologica.) *London: Percy Lund Humphries and Co.*, 1939. 11×8½ *inches;* vi+390 *pages; maps.* 35*s*

This, the second volume of Anthologia Anthropologica, contains material from Sir James Frazer's notebook which, in the main, he has not used in his published works. Here is collected a vast amount of miscellaneous information concerning the social anthropology of Australasia and Indonesia culled mostly from the accounts of early travellers, missionaries, and others. Thus it forms a storehouse for which students will be grateful to Sir James in allowing them to share the benefit of his erudite and meticulous labours. Of particular value to English students are the translated extracts from Dutch authors relating to the ethnology of Indonesia. In some cases references are given to recent literature. It is necessary to consult the useful index when information is required about a special area or people as it may be distributed in different sections. The editor should have included the Trobriand islands and the D'Entrecasteaux group in New Guinea rather than in Melanesia, and similarly the Philippine islands and Formosa should be included in Indonesia and not in Micronesia. The worst slip however is the allocation to Torres Straits of the Banks islands which lie to the north of the New Hebrides. A. C. H.

PHYSICAL AND BIOLOGICAL GEOGRAPHY

EROSION AND SOIL CONSERVATION. By G. V. JACKS and R. O. WHYTE. (Herbage Publication Series. Bulletin No. 25.) *Aberystwyth: Imperial Bureau of Pastures and Forage Crops*, 1938, 9½×7½ *inches;* 206 *pages; maps and diagrams.* 5*s*

The avowed object of the authors of this study, modestly described as a "paper," is not to give technical details of soil-conservation and erosion-control methods, but to assess the present status in the matter of causes, extent, palliation, and cure of erosion damage in those countries most affected. The areas treated involve the Mediterranean (Italy, Cyprus, Turkey, and Palestine), U.S.S.R., India, Ceylon, East Indies, China, Japan, France d'Outre-mer, South Africa, Rhodesia, East Africa, West Africa, U.S.A., Canada, West Indies, Australia, and Fiji. The report, being based on publications and correspondence rather than first-hand observations, necessarily gives very unequal attention to the various countries. But this striking inequality is in itself a measure of the progressiveness of some governments in their attack on what is rapidly becoming a world-wide problem. The U.S.A. and Canada have so far outstripped the rest of the world in this respect that the sections of the report devoted to them are each subdivided, and the list of references cited is admittedly only a fraction of the publications on a matter which has become the subject of extensive legislation and consequently an important plank in political platforms. The material has been well digested and the resulting résumés of the situation in the various countries are valuable, especially in cases like the U.S.S.R., where the language puts the data beyond the reach of most readers. The extent to which some governments have already gone to meet the problem is little realized. The French have spent 317 million francs on reforesting over a million acres, while dune-stabilization has been carried out along 720 miles of coast. In 1937–38 Canada appropriated £400,000 for rehabilitation of drought and soil-drift areas in Manitoba, Saskatchewan, and Alberta, while the estimated total investment

of U.S. government funds in the Tennessee Valley project alone up to 1943 will exceed £90,000,000.

Thus far the U.S. Department of Agriculture is the only government agency that has embarked on a country-wide policy of educating public opinion on this vital question. The report under review appeared just too early to include reference to the excellently illustrated popular conservation publication 'To hold this soil' (U.S. Dept. Agric., Misc. Publ. 321), which gives a scientifically accurate account of the problem in a racy style, despite its fairly heavy load of statistics and technical detail.

In other regions experience in the scientific handling of the problem on plantations has led to a general recognition of certain principles which are accepted in practice without the need of any program of public enlightenment on the subject. Thus, to quote from the section on Malaya, which, incidentally, is comparable to Ceylon in its erosion conditions, "the consequences of clean-weeding sloping estates have long been recognized and were formerly obviated or delayed by bunding and digging silt pits on contours to catch the run-off and eroded soil. Terraces are regarded as the main line of defense." The report enumerates the best perennial rapid-growing plants with creeping habits and well-developed root systems which are suitable both as soil-stabilizers and as green manures under various soil conditions.

In many countries the published results of research on erosional problems has not got beyond the somewhat academic level of soil analysis, crop acreage, and rainfall data. Others have reached the stage of connecting areas of worst erosion damage with definite combinations of rainfall, slope, geological terrain, or deforestation. But for the most part there is evidence of a growing realization in all parts of the world of the serious implications of the steady impoverishment of the land by top-soil stripping as well as by the grosser aspects of denudation. It will be interesting to see what the picture will be in 1949. Meanwhile the present study deserves the serious attention of fore-sighted authorities, who will find it as significant for its implications as for the facts it makes available at low cost. It is the most generally valuable of the Herbage Publication Bulletins thus far produced. G. B. B.

GENERAL

COMMERCIAL GEOGRAPHY. By H. ALNWICK. (Harrap's New Geographical Series. General Editor: R. N. RUDMOSE BROWN.) *London: George G. Harrap and Co.*, 1939. 10×7 *inches;* 216 *pages; sketch-maps and diagrams.* 4*s* 6*d*

This book should prove of value for pupils of about fifteen years preparing for a first examination. In Part I commercial geography is presented on a climatic basis with consideration of products of hot, warm, and cool lands. This has had to be supplemented by a survey of animal, mineral, and factory products which are independent of climatic boundaries. Part II is concerned with the trade of countries, commodities, trade routes, and trading centres. There is a useful forty-five-page appendix giving facts relating to the nature, production, use of, and trade in the chief commodities as well as a set of climatic statistics about places and crops. The exercises which accompany each section are comprehensive and call for thought and sifting of material on the part of the pupil. Diagrams are abundant and varied but somewhat overcrowded by symbols and writing; some of the information so written on the illustrations would be better placed in the text. Adjoining maps showing distributions of commodities are without scales, *e.g.* Fig. 40. In the diagram on p. 115 showing the trade of six

countries by circular graphs, the shaded sectors are placed at random in the circles, and moreover the use of circles of equal size for the trade of New Zealand, U.S.A., etc., is misleading. Fig. 37, purporting to show the "Three major regions" on the basis of mineral and cash crop productions is useless in that the tacit assumption is a north–south movement of commodities, whereas later figures (Fig. 40) display the truer picture. A. C. O.

THE STORY OF THE WORLD. Edited by JOHN H. REYNOLDS and G. E. S. COXHEAD. *London: Universal Textbooks*, [1938]. 10½×7½, viii+534 *pages; illustrations and sketch-maps.* 8*s* 6*d*

The editors of this volume aimed at simplicity and accuracy: an introduction to world geography by means of concise but interesting accounts of the various countries, liberal illustrations, and maps. There is a good deal of miscellaneous information contained in the text, and the method of approach varies for each country. Special emphasis has been placed on the lands that come within the British Empire. The maps are purely pictorial. The plates have been well chosen and add considerably to the interest of the volume. Their reproduction is somewhat crude, as is the colouring of the maps, but in view of the price more could not be expected. There is an index. One of the editors was the late Mr. J. H. Reynolds, who took care to see that P.C.G.N. spellings were adopted throughout. It might be noted that the siege of Gibraltar mentioned on p. 32 took place in 1779.

EAST OF ATHENS. By ERIC GIFFORD. *London: The Travel Book Club*, 1939. 8½×5½ *inches; 256 pages; illustrations.* 12*s* 6*d*

Mr. Gifford is an artist who has on several occasions travelled in the Near East in search of subjects for his brush, and here gives us eleven examples of his skill. All are economic of line and harmoniously composed, but unfortunately they are too sketchy to be revealing. Much the same criticism holds good of the text, which is a by-product of his artistic tours. The writing, easy, skilful, and unpretentious, records faithfully what the author saw and did. Feeling however that he must be bright at all costs, he has restricted himself to the petty incidents of everyday travel in the Near East. After plunging into a description of, say, St. Sophia or Petra which delights us by its accurate observation and its pleasant choice of words, he suddenly stops to dilate at much greater length on the wretchedness of the local café or the lateness of his boat. One ends the book knowing nothing new of the places—Corfu, Athens, Constantinople, Rhodes, Cyprus, Cairo, and the Isles of Greece—to which his fancy led him. He has also fallen so often into the unsympathetic mood which is the usual penalty of brightness-at-all-costs that he makes us wonder if there are no nice people at all in the Near East. His sense of character is generally so weak that he leaves Jew and Gentile, Greek and Turk indistinguishable. M. M. H.

THE MONTHLY RECORD

SARDINIAN STUDIES

A visit by members of the Le Play Society to the island in 1934 has resulted in the publication of a brief volume of 'Sardinian studies' (London: Le Play Society, 1938, 2*s* 6*d*), edited by Mr. W. G. Walker. There is a very clear description, with a map, of the geology of the island, followed by an account of its archaeology by the editor which forms the principal item of study. Because of volcanic activity, the occupation of Sardinia did not commence till Neolithic times, and the first arrivals came apparently from Africa. Identity of race and the insular working out of ideas received from outside culminated in the Bronze Age Nuragic civilization, peculiar to the island and flourishing from about 900–200 B.C. Mr. Walker describes the structure of the *nuraghi*, which were the strongholds of tribal chiefs and not conquerors' fortresses. The fate of Sardinia, conquered by the Carthaginians and then by the Romans, and thus uninfluenced by Greek culture, is briefly related. There are useful maps of Nuragic, Punic, and Roman sites. There is a brief and not very sympathetic account of ecclesiastical architecture on the island, together with notes on the solid-wheeled ox cart, on the zinc mines at Montefiori, and on the flora. Altogether the studies form a useful and adequately illustrated introduction to the island. E. S. Bouchier's 'Sardinia in ancient times' is mentioned, but no further sources are given. Otherwise attention might have been drawn to the 'Atti del XII Congresso Geografico Italiano,' published in Cagliari in 1935 and already reviewed in this journal (*Geogr. J.* 89 (1937) 560–62), which deals exclusively with Sardinia and has a number of very useful maps.

SCIENTIFIC INVESTIGATIONS IN ICELAND

We have received through the courtesy of the Foreign Office a translation of a resolution recently adopted by the Icelandic Parliament regarding scientific work in Iceland. The resolution states that there is need for more extensive and better organized investigations into the nature of the country, and that these should be undertaken as far as possible by Icelandic scientists. No such investigations, ethnological research, or similar inquiries, are to be carried out by foreigners except with the permission of, and in cooperation with, the Board controlling scientific investigations in Iceland. We understand that the chairman of this Board, to whom applications to undertake research should be made, is M. Steinthór Sigurdsson, Asvallegata 11, Reykjavik.

THE GEOLOGICAL HISTORY OF THE LAKE RUDOLF BASIN

Although, as Dr. Fuchs points out, Lake Rudolf itself can hardly be said to lie within the Rift, all who are interested in the geological history of African rift valleys, their physical geography, tectonics, or prehistory should read this paper (*Philos. Trans.*, No. 560, vol. 229, 1939, pp. 219–74). The research described in it is not new to its author, and it is to be hoped that he may be able to follow up this preliminary work by further investigations to the east of Lake Rudolf (which he would have been able to make but for the loss of two of his companions), and in other areas. He has steered an excellent course between too much detail and not enough; his paper is not only of interest on account of its subject-matter but is in addition readable and not too long. As a contribution to rift valley geology it is of permanent value, and will be especially welcomed by those interested in the physiographic vicissitudes of the Pleistocene in relation to human occasions in the heart of Africa. The results are of more

than local significance. They much extend the established parallels of events and of the times of their occurrence in other parts of the rift valley system in Kenya, Tanganyika, and Uganda, widening the unit area for comparative purposes to well over 3,000,000 square miles—but the boundaries of this unit, if such it may be called, are yet far to reach.

In the year 1919 the reviewer's field investigations near Lake Albert convinced him that the classical tension theory of the rift would not work (in that area at least), and in 1921, because of a controversy which had sprung up between Professor J. W. Gregory and Dr. John Ball, of the Egyptian Desert Survey, he set out in the pages of this journal a heterodox hypothesis (that of compression) to account for the rift. About this time, too, as Fuchs points out, Ball concluded on purely general grounds that "the structures observed by Professor Gregory are far more likely to be the relics of faulting due to compression and compressional shearing such as we are familiar with elsewhere on the earth than to the very peculiar conditions which the trough fault theory demands." The work of Fuchs and his colleagues supports Ball's view more strongly than their scientific caution allows them to admit. It must be seldom that so much direct evidence of compression is observable in relation to rift valleys, for if, as the reviewer believes, the compression is deep seated and mainly effective during periods of continental uplift, it must most commonly happen that superficial adjustment to deep-seated displacement will take the form of sagging and then collapse from above, so that little or nothing but normal (gravitational) faulting is exhibited at the surface.

Fuchs expresses the belief that although "it has usually been thought that the central African peneplain was first disturbed in late Cretaceous times . . . rifting proper did not begin until the late Oligocene." This would appear to be so in the Rudolf area where the erosion of the basement rocks occasioned by this new relief gave rise to the Turkana grits which were subsequently covered by Pliocene lavas, but there is evidence in Uganda that suggests the major rift fractures are extremely old, and that the original rift and its sedimentary contents may have been peneplained out of all expression before the late Oligocene rifting (which would thus be a recrudescence of movement) took place. There was great rifting, recrudescent or otherwise, about that time in Uganda, for a borehole put down near Butiaba passed through rather more than 4000 feet of sediment before striking the crystalline bottom of the Albert rift, and the lower 688 feet of these deposits, which are unconformable to the beds above them, yielded plant remains of mid-Tertiary aspect similar to those of the Bugishu beds (*cf.* the Turkana grits). Further movements took place in the Pliocene and Pleistocene.

The periods of major earth-movement (with or without volcanicity) in the Rift Valley as recorded by Fuchs coincide most strikingly with those worked out in Uganda, Kenya, and Tanganyika, but what is even more gratifying is that the essential correctness of the Pleistocene climatic sequence determined in those places is further demonstrated by their identity with Fuchs's discoveries in that direction.

In Uganda, after the deposition of the Kisegi and Kaiso beds, during what the reviewer has called the First Pluvial and its decline, came a long arid period—a dry-out—and the extinction of the Kaiso fauna, while in the Rudolf region we have the deposition of the Gaza beds (=Kisegi?) and the Omo beds (=Kaiso) preceding a similar dry period that accomplished the extinction of the pre-Nilotic fauna of these parts. Then, in both areas, in pre-E. A. Chellean and Chellean times came a great rise of the lakes, to be followed, again in both areas, by a fall (but not a dry-out) culminating in Chelleo-Acheulean or early Acheulean times;

again the lakes rose and dropped while the Acheulean passed through several more stages and came to its close; subsequently still another rise (Leakey's Gamblian) and fall occurred, only to be succeeded by some smaller oscillations. These happenings are paralleled event by event, time by time, and culture by culture not only between the Rudolf basin and other parts of the Rift Valley in Kenya but also in Tanganyika and Uganda. One may go much farther afield in the tropics and find at least general but none the less striking parallels; the significant fact that emerges is that in the work of Fuchs and his colleagues we have a further demonstration that the African rift valleys, discontinuous as they may appear, are part of a tectonic whole of continental significance, and that the climatic episodes of Pleistocene days in Eastern and Central Africa were neither merely local, as some seem disposed to think, nor of short duration, but that they, like the tectonic events that gave expression to the rift valleys, are of continental significance too. Indeed, it will one day come to be generally admitted that they were regional expressions of changes in thermodynamic interplay in the world's atmosphere occasioned by extra-terrestrial and secular conditions which obtained during the most important period of man's emergence—conditions, indeed, that may have played no small part in his development. E. J. W.

SETTLEMENT IN BRITISH GUIANA

By its terms of reference, the British Guiana Refugee Commission, which has recently issued its report, was directed to study the "suitability and practicability of large-scale colonization in British Guiana for involuntary emigrants of European origin," and to estimate the approximate numbers that might be settled there immediately and over a period. The main area available for examination lay south of lat. 5° N. to the Brazilian boundary. West of the Essequibo river, about 4400 square miles of the total area (22,500 square miles) is open savannah, the remainder of the area and the 15,000 square miles east of the Essequibo and Courantyne rivers being forest. The Commission were of opinion that the basis of the proposed settlement should be self-sufficient agriculture, and that other necessary economic developments might follow later. A further consideration was that of accessibility, in relation to the initial settlement and to future communication with world markets. Finally, aspects of public health and sanitation were considered.

Investigation showed that the only fertile soils immediately suitable for permanent agriculture were to be found in the Kanuku type of valley, west of the Rupununi river, and in the Parakaima valleys on the Brazilian boundary. This soil in the Kanuku area appeared to have been derived from the basic rocks of the range. In the Rupununi gorge it is chocolate-coloured and associated with a characteristic palm, *Orbignya sagotii*. From the evidence afforded by the sighting of stands of this palm from the air and from the reports of settlers, the Commission was satisfied that in the valleys of the Kanuku and other associated ranges this fertile soil exists in substantial quantities.

Owing to the isolation of these areas, the question of communications is of great importance. The Commission considers that a motor road would be more suitable than a railway, and that it should be cut through the forest area from the limit of deep-water navigation on the Berbice river, probably at Takama, to Annai on the lower Rupununi, rather than that the existing Bartica–Potaro road should be extended in this direction. As regards health, the Commission consider that the interior of British Guiana is suitable for carefully planned settlement by people from central Europe.

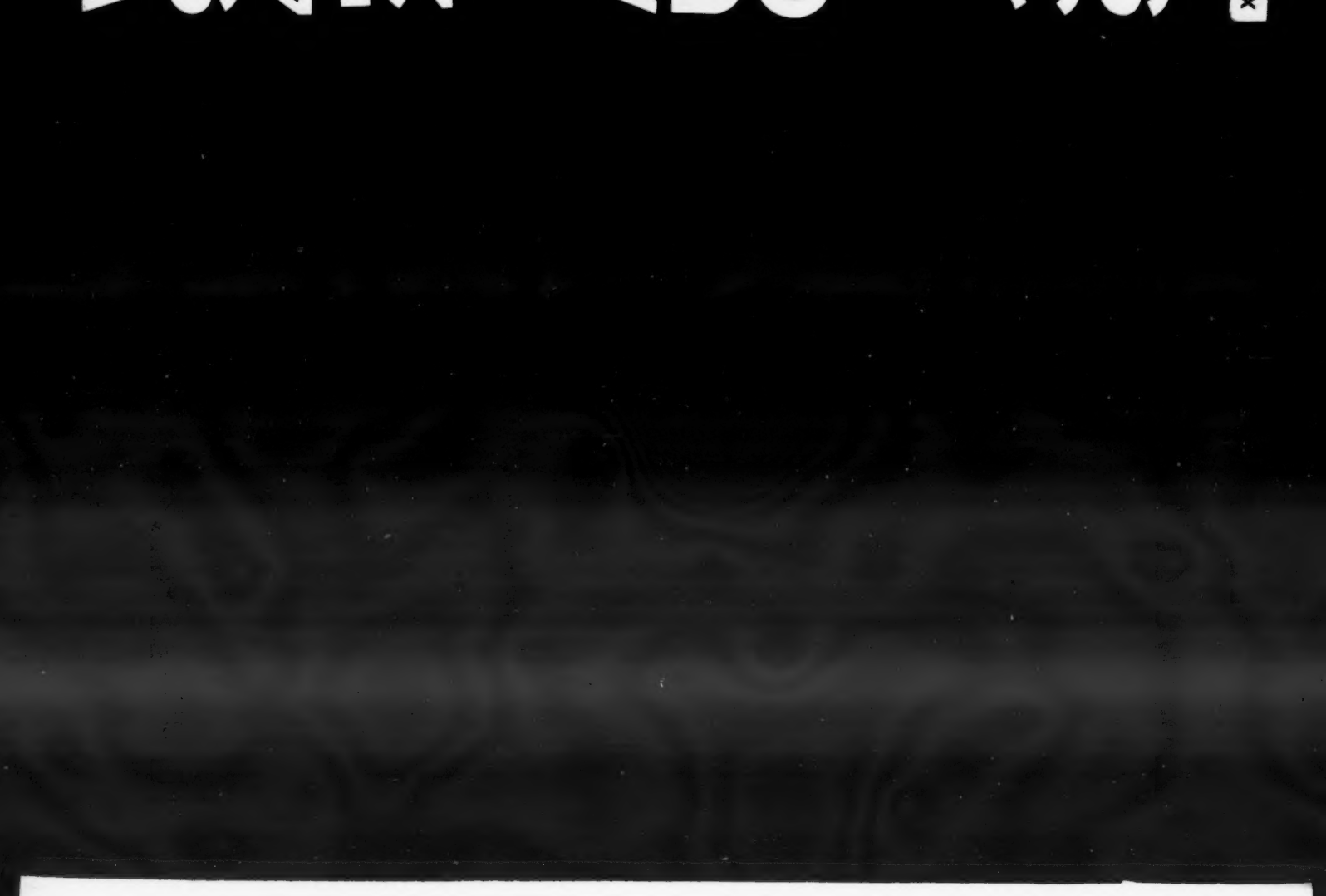
The Commission reported therefore that the area south of lat. 5° N., though

not ideal, has potentialities which justify trial settlement on a considerable scale, but are careful to distinguish this from suitability for immediate settlement. The Commission proposes the establishment of trial settlements on the Kanuku type of soil on the open savannah, to experiment in improving the cattle raised at present, and of a mixed agricultural and pastoral settlement on the savannah near a fertile valley, this to be designed as a prototype village for the future settlements. This work, including that on the lines of communication, is estimated to require three to five thousand people at an approximate cost of three million dollars for the first two years. As the ultimate aim is large-scale settlement, it is emphasized that a soil survey is necessary to plot accurately the distribution of Kanuku and other types of soil and to determine whether their area is as extensive as the preliminary examination suggests. The proposed transport route also requires to be surveyed, and a scheme for the establishment of rest camps and sanitary control, and the training of crews for river work to be formulated. The soils of the Parakaima plateau, where hill stations might be placed, should also be examined. The Commission also set out a number of other questions to be examined before close settlement, possibly with subsidiary industries, should be undertaken.

The Report is accompanied by appendixes by members of the Committee; among them may be mentioned Sir Geoffrey Evans on the possibilities of agricultural settlement, Colonel R. V. Nicholas on the development of transport routes, and Doctor A. Donovan on the health aspects.

OBITUARY

THE RT. HON. SIR MATTHEW NATHAN, G.C.M.G.

Sir Matthew Nathan, who died on April 18, had seen much military and administrative service abroad and at home. At the beginning of his career he served with the Royal Engineers, working on the Sudan railway during the campaign of 1884–85, and taking part in the Lushai expedition of 1889. With his appointment as Secretary of the Colonial Defence Committee in 1895, he entered upon a new field of activity in which his administrative abilities had full scope. After administering Sierra Leone, he was appointed Governor of the Gold Coast, where he had to deal with the after effects of the Ashanti war, and the building of the railway into the interior. Later he was Governor of Hong Kong, when the Canton–Kowloon railway negotiations were completed, and last Governor of Natal before the Union. In 1909 he began a period of service at home which included two years as Under-Secretary for Ireland. After the War he went to Australia as Governor of Queensland for five years. There he became interested in the problems of the Great Barrier Reef, and with Professor H. C. Richards established a committee to initiate research in that area. On his return home he secured the cooperation of the Civil Research Committee, which resulted in the Great Barrier Reef Expedition of 1928–29, led by Dr. C. M. Yonge. During his retirement in Somerset Sir Matthew interested himself in local affairs—he was Sheriff of the County in 1934—and for some years before his death was engaged in collecting material for a history of the Manor of West Cocker.

Sir Matthew had been a Fellow of our Society for forty-two years. He served on the Council for several years, and was a Vice-President from 1929 to 1933. To the Library he presented a collection of books on West Africa.